ROYAL BOTANIC GARDENS, KEW.

BULLETIN
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MISCELLANEOUS INFORMATION.

No. 9] [1922

# XXXIX.—OOSPORES IN CULTURES OF PHYTOPHTHORA FABERI.

S. F. Ashby.

*Phytophthora faberi*, Maubl. the cause of podrot, patch canker and chupon wilt of cacao has been reported from most parts of the tropical Old and New Worlds where the tree is cultivated. It has been isolated and studied in pure culture by a number of authors, more particularly by Coleman, Rosenbaum, Rorer and McRae. Coleman and Rorer mention the finding of bodies in nature which they believed were oospores and Coleman saw similar bodies in cultures; these bodies however were devoid of antheridia and were in all probability nothing but chlamydospores which are developed freely by the fungus on and in the pod wall and in pure cultures. Neither Rosenbaum nor any of the other investigators who have worked with the fungus has reported the finding of oospores. The writer has repeatedly isolated this species from cacao in Jamaica and more recently from cacao in Grenada but has never seen a trace of oospores in pure cultures on a variety of media including bean, oat and corn meal agars. The outcome however is different when the cacao fungus is grown in mixed culture with more or less related forms. In Jamaica two species of *Phytophthora* attack the coconut palm, one being a strain of *P. parasitica*, Dast. while the other, which is the cause of a serious budrot, closely resembles the cacao fungus. It also has never been found to develop oospores in pure culture and the same observation applies to a *Phytophthora* isolated in the present year from rotting cotton bolls in St. Vincent which in its vigour of growth, mycelial characters and asexual reproduction appears to be identical with the form from the budrot of the coconut. (This *Phytophthora* from cotton bolls in St. Vincent is quite distinct from the species isolated by Miss E. M. Wakefield from cotton bolls in Montserrat which both she and the writer consider to be a strain of *P. parasitica*). In pure culture the cacao fungus differs

from the coconut and cotton-boll strains in growing less vigorously and in developing sporangia less luxuriantly but chlamydospores more freely; it does not form the characteristic mycelial aggregates usual in cultures of the coconut form. In all other respects including conidiophores and shape and size of the sporangia the three fungi cannot be distinguished in pure culture. Neither the coconut nor the cotton boll form has been found to infect cacao pods.

The first observations on mixed cultures were made when the writer was working in the Mycological Laboratory of the Ministry of Agriculture at Kew (now the headquarters of the Imperial Bureau of Mycology) in the summer of 1920. Pure and mixed cultures of the cacao and coconut budrot *Phytophthora* isolated in Jamaica were grown on slants in tubes of French bean agar for two months (July–September) in an incubator at 25° C. The two *Phytophthora* were inoculated in the mixed cultures by placing a fragment of agar carrying growing mycelium at two points on the slant about one inch apart. A colony of each form developed independently and after a few days they met and mingled. At the end of two months the pure cultures contained no oospores but they had developed freely in the mixed cultures throughout the colony of the cacao fungus and as far as the centre of the other growth. The mature sexual bodies were of the "*infestans* type" with persistant antheridia and a golden-yellow thickened oogonial wall. The mean size of 46 oospores was $23 \cdot 3\ \mu$ and the extremes were 19 and $26 \cdot 5\ \mu$; the oogonial wall averaged $29\ \mu$ with a variation from 25 to $32 \cdot 5\ \mu$. The result of growing the two forms in mixed culture with strains of *P. parasitica* will be considered later.

In order to confirm these findings, if possible, pure and mixed cultures of the cacao, coconut and cotton boll *Phytophthora* were grown in Barbados during the present year. The cacao culture was a recent isolation from a diseased pod in Grenada, the two cultures from the coconut had been isolated in Jamaica some years earlier while the cotton boll culture was a recent isolation from St. Vincent. The *Phytophthora* were grown on slants in tubes from a single batch of lima-bean agar.*

Five successive transfers of the pure cultures were made, after growth for two days, before mixed cultures were prepared in

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* The medium employed was a thin lima-bean agar prepared from white mature beans. 100 grams of whole beans were soaked in a litre of water for two hours and then steamed in an Arnold steriliser for three-quarters of an hour. The extract was poured off the beans and they were pulped in a mortar and the pulp returned to the extract, the mixture filtered through muslin and the latter squeezed. 16 grams of "bacto" agar were added and the liquid boiled for a few minutes and poured through coarse muslin. It was tubed and sterilised in the autoclave at 12–15 pounds pressure for 20 minutes. This mode of preparation yielded a nearly clear agar with a deposit of unruptured cells. It was sloped without raising the sediment.

the way described above. Each combination was run in duplicate by reversing the position of the two colonies on the slant. The cultures stood on a table under a large bell jar in subdued light from the middle of April to the middle of July when they were examined. The temperature of the room seldom exceeded 30° C. and was never below 22° the mean being near 26° C. No oospores could be found in any of the pure cultures and they were not present in the mixtures of the two coconut cultures nor in the mixtures of those with the cotton-boll culture. Oospores were present, however, in all the mixed cultures containing the cacao *Phytophthora*. In these mixtures of the cacao fungus with the two coconut cultures and the cotton boll culture the sexual spores were of the "*infestans* type" with a yellow more or less thickened oogonial wall. The thick-walled hyaline oospore filled the oogonial cavity, as a rule, leaving only a dark line between the walls, but examples were frequent in which the oospore did not fill the cavity. A persistant antheridium was always present, usually hyaline but occasionally stained yellow. The oogonia and antheridia always appeared to be developed on separate hyphae but it was not possible to trace these hyphae definitely to the same mycelium. The interesting observation was made that in a few examples no walled oospore was present but the plasmatic contents completely filled the mature thick-walled yellow oogonium, the wall of which showed the pitted appearance characteristic of the mature chlamydospore; in all such cases a perfect persistent antheridium was present. The oospores were developed in the dense surface plectenchyma, and to a depth of about 2 millimetres below it: they were scanty at greater depths in the agar. In some portion of the slants, the mature oogonial wall showed a dark, rather indefinitely limited outer zone with a rough or wrinkled surface but elsewhere this zone was lacking and the wall appeared to be smooth. Oospores were abundant throughout the growth area of the cacao *Phytophthora* but became scanty towards the centre of the other colony. There was mutual penetration of the two colonies but the vigorous coconut and cotton-boll strains appeared to push into the colony of the cacao fungus deeper than the latter did into their zones. This tendency was clearly shown in some additional mixed cultures in which a colony of the coconut *Phytophthora* was allowed to develop for two days before the cacao fungus was inoculated on the upper part of the slant. In these examples, oospores were present up to the apex of the slant and the mycelial aggregates of the coconut strain were present at the apex also, indicating that it had grown through the cacao colony. A series of transfers of the pure cultures at short intervals did not appear to be necessary for subsequent development of oospores in the mixed cultures as they were formed abundantly when the cultures were mixed after one such transfer.

The mean size and variation of the oospores were approximately the same in all combinations of the cacao with the coconut

and cotton-boll *Phytophthora* with the exception that when a colony of a coconut culture was inoculated on a slant two days ahead of the cacao inoculation, the oospores which developed were on the average smaller than when the inoculations were made simultaneously. The data are summarised in the table showing the results for all cultures.

The absence of oospores from pure cultures of the three *Phytophthora*, their close relationship as indicated by the mycelial growth and the size and shape of the asexual spores, and the more vigorous growth of the coconut and cotton boll strains which appear to be identical suggested rather strongly that all may be strains of one heterothallic species, the two vigorous forms being plus strains and the more weakly growing cacao form a minus strain. The behaviour of cultures grown from the oospores might be expected to throw further light on this hypothesis but unfortunately attempts to germinate them have not met with success, hitherto. The results moreover of growing the cacao and coconut forms in mixed cultures with strains of *P. parasitica* do not support that view. When the author was at Kew a mixed culture of the cacao *Phytophthora* isolated in Jamaica was grown on French bean agar with a strain of *P. parasitica* isolated from *Ricinus communis* in India by J. F. Dastur. The culture was maintained for two months in an incubator at 25° C. and then examined. Oospores were present in the cacao colony, averaging 23·6 $\mu$ in diameter with a variation of 20–25·3 $\mu$. Pure cultures of *P. parasitica* from castor develop oospores having a mean diameter of 18·6 $\mu$. The form from budrot of the coconut was grown at the same time in mixed culture with a strain of *P. parasitica* from the coconut, which in pure culture developed oospores having a mean diameter of 19·3 $\mu$. Oospores were numerous in the growth zone of the budrot form and in that of the "parasitica" strain but they were of the same size throughout the mean being 19·2 $\mu$. The fact that oospores of the same type and the same mean size and variation are formed in all mixed cultures of the cacao *Phytophthora* both with closely related forms and with an unrelated species indicate that the oospores are actually those of *Phytophthora faberi*. It is of interest to note that the oospores of the strain of *P. parasitica* developed in contact with the growth of the *Phytophthora* from coconut budrot were of the same size as those in pure culture.

The oospores of *P. faberi*, which have normally a mean diameter of 23·1–23·6 $\mu$ and a variation of 17·8–28·6 $\mu$, are substantially larger than those of *P. parasitica* (mean of 18·6) but approach closely in size to those of *P. meadii*, McRae (mean of 24·50) and *P. colocasiae*, Rac. It is evidently distinct from the last species. The coconut *Phytophthora* is apparently identical with *P. palmivora*, Butl. which should include provisionally the form which the writer obtained from cotton-bolls in St. Vincent. The absence of oospores both in pure and mixed cultures of this

species and some growth differences as well as its inability to infect cacao pods, distinguish it from *P. faberi*. It would seem to the author no more justifiable to include it in one species with *P. faberi* than to unite it with *P. meadii*.

*P. palmivora* might prove to be a useful species for growing in mixed cultures with other forms which develop oospores in pure cultures either scantily or not at all. *P. nicotianae*, Br. de Haan appears to be such a species concerning the oospores and relationship of which nothing very definite is known although it is a destructive parasite on tobacco in some parts of the East.

*Table showing Cultures in which Oospores were present or absent and their Mean Size and Variation.*

| Culture. | Oospores. | | | Oogonial wall. | |
|---|---|---|---|---|---|
| | Number measured. | Mean diameter. | Variation. | Mean diameter. | Variation. |
| 1. Pure cacao. p. - | none | — | — | — | — |
| 2. Pure coconut p. no. 2 | none | — | — | — | — |
| 3. Pure coconut p. no. 3 | none | — | — | — | — |
| 4. Pure cotton boll p. | none | — | — | — | — |
| 5. Mixed coconut p. 2 + 3 | none | — | — | — | — |
| 6. Mixed coconut 2+cotton boll | none | — | — | — | — |
| 7. Mixed coconut 3 and cotton boll | none | — | — | — | — |
| 8. Mixed cacao + coconut 3 | 46 | 23·3 | 19–26·5 | 29·0 | 25–32·5 |
| 9. Mixed cacao + coconut 3 | 52 | 23·1 | 17·8–27·8 | 28·6 | 22–35 |
| 10. Mixed cacao + coconut 2 | 30 | 23·1 | 19–28·6 | 28·9 | 21·8–35·5 |
| 11. Mixed cacao + cotton boll | 84 | 23·5 | 17·8–28·6 | 29·0 | 22–35 |
| 12. Mixed cacao + "parasitica" (castor) | 22 | 23·6 | 20–25·3 | 28·8 | 25–33 |
| 13. Pure "parasitica" (castor) | — | 18·6 | 15·6–20·4 | 22·6 | — |
| 14. Mixed coconut 3 + "parasitica" (coconut strain) | 30 | 19·2 | 16–21·5 | 23·5 | 20–26 |
| 15. Pure "parasitica" (coconut) | — | 19·3 | — | — | — |
| 16. Mixed cacao + coconut 3 (coconut 3 inoculated 2 days before cacao) | 43 | 22·0 | 17·8–27·3 | — | — |

All measurements in terms of $\mu$.

## REFERENCES.


Coleman, L. C. - Diseases of the Areca Palm (Areca catechu, L.). I. Koleroga or rot-disease. Ann. Mycol., VIII, p. 591, 1910.

Rorer, J. B. - Pod-rot, canker, and chupon-wilt of Cacao caused by Phytophthora sp. Bull. Dept. Agric. Trinidad, IX, No. 65, 1910.

Rosenbaum, J. - Studies of the genus Phytophthora. Journ. Agric. Res., VIII, p. 233, 1917.

McRae, W. - - Phytophthora Meadii n. sp. on Hevea brasiliensis. Mem. Dept. Agric. India, Bot. Series, IX, No. 5, 1918.

Butler, E. J. & Kulkarni, G. S. Colocasia blight caused by Phytophthora Colocasiae Rac. Mem. Dept. Agric. India, Bot. Series, V, No. 5, 1913.

Butler, E. J. - Fungi and Disease in Plants, Calcutta, 1918.

Dastur, J. F. - On Phytophthora parasitica nov. spec. Mem. Dept. Agric. India, Bot. Series, V, No. 4, 1913.

Ashby, S. F. - Notes on two diseases of the Coconut palm in Jamaica, etc. West Indian Bull., XVIII, p. 61, 1920.

Ashby, S. F. - Relation between Cacao pod rot and Coconut bud rot. Agric. News, Barbados, XX, No. 507, p. 318, 1921.


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# XL.—THE FRUITING OF GINKGO BILOBA AT KEW.

W. Dallimore.

Considerable interest was created by the publication in *K. B.* 1920, p. 47, of a note on the fruiting of *Ginkgo biloba* Linn. (the Maidenhair Tree) at Kew. The "fruits" (seeds), some 4 or 5 in number, were produced during 1919 on an old male tree near the Main Gate, the fruiting branch having been grown from a graft of a female tree obtained in 1911 from the Director of the Montpellier Botanic Garden.

The note gave rise to correspondence casting doubt upon the truly dioecious character of the species and in October 1920 Professor F. A. F. C. Went of Utrecht wrote :—"In connection with this note I should like to make a few remarks on the fruiting of a male *Ginkgo* tree in the Botanical Garden of the University of Utrecht. There is a very old male tree in that garden whose early history is unknown, but its age is perhaps more than one hundred years. The diameter of the stem at ground level is more than one meter. For many years the tree stood in the shadow of some large elm trees. These were removed five years ago, in order to get space for the building of a new laboratory. The consequence was that the tree got more sun, and the upper branches have since considerably developed.

"In recent years the tree has blossomed frequently and, just as at Kew, 'so profusely as to litter the ground beneath it with its small green cylindrical inflorescences.' Only in the autumn

*Plate I.*

GINKGO BILOBA.

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of 1918 one branch was seen bearing several bright yellow 'fruits.'

"It was evident that this was a small female branch and the question arose, how was this possible? Was it a case of a male tree producing one female branch or was it possible that this branch had formerly been grafted on the tree? This last supposition seemed to be improbable because the branch grows at the height of about twelve meters above the level of the earth. Moreover why did it never before bear fruits? At least I am sure that since 1896, when I became Director of the Garden, no fruits have been produced. They are too conspicuous to be overlooked.

"I thought this phenomenon curious enough to be worth noting. Is it possible that the alteration of the conditions mentioned above has been the cause of the production of these female flowers? No fruit was observed in the years 1919 and 1920, though possibly female flowers may have been produced on that branch, but they are so inconspicuous that it is not easy to detect them at such a height."

A curious fact relating to the *Ginkgo* was revealed in 1914 by His Majesty the King of Italy who asked Sir David Prain if the Maidenhair Tree at Kew produced fruits. When told that it did not His Majesty explained that he had two examples of the tree in the Quirinal Garden which fruit profusely every season in spite of the fact that there is no male tree there and that so far as His Majesty could ascertain there is no example of a male Ginkgo in Rome.

Mr. E. H. Wilson* who has a wide knowledge of the maiden-hair tree in China, Japan and North America says "The trees bear either male or female flowers but the two sexes are never found on one and the same individual unless deliberately grafted together."

Professor Chodat writing from the University of Geneva in November 1920 to Dr. A. W. Hill concerning the Utrecht tree says "I would rather be inclined to believe that in the case reported by Professor Went, a female branch has been at some time grafted on the male tree as it has been done in several botanic gardens.

"Here we have in the Jardin des Bastions side by side both male and female trees but I never observed that the male should bear female catkins or fruits or the reverse."

In referring to the fruiting of female trees in the absence of pollen-bearing specimens he adds.—"But the beautiful female tree in the Jardin du Lai (formerly Jardin Anglais) about one mile distant is quite isolated. This year, and I have made the same remark for many years, this tree is covered with well developed fruits.

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* The Romance of our Trees, p. 69 (1920).

"Is it fertilised by the pollen grains brought by the wind, or is it parthenogenetic I do not know? The case should be investigated. We may try to solve the problem."

We hope that Professor Chodat will undertake this investigation for despite, or perhaps because of, its antiquity *Ginkgo* appears still to possess morphological problems that would well repay scientific research. It was only in 1895 and 1896 that Professor S. Hirase carried out in Tokyo* the experiments which resulted in the discovery that motile male sperms take part in the fecundation of *Ginkgo*, this genus therefore like the Cycads (which also possess motile male sperms) is to some extent intermediate between other flowering plants and ferns. The reason for the belated maturation of the embryo in the seed is another interesting problem, the embryo sometimes does not complete its development until after the fall of the seed. Research work in Britain would be difficult owing to the scarcity of female flowers but there are plenty of female trees on the Continent that flower and fruit every year, and where these trees exist investigations might be made.

So far as is known the fruits matured by the Kew tree in 1919 were the first to be ripened in Britain and there have been no more until the present year. There are now two large clusters, as shown by the accompanying photograph.

Returning to the Utrecht tree there is an interesting problem respecting it, in addition to the fruiting branch, as it may very well be the first *Ginkgo* introduced into Europe. The species was first made known to Western botanists by Dr. Engelbert Kaempfer, a surgeon in the employ of the Dutch East India Company, who in the course of business visited Japan in 1692. On his return to Holland he wrote several books on botany and travel and in 1712 published his *Amoenitatum Exoticarum*, on p. 811 of which he gave a description of *Ginkgo* with a full plate drawing of shoot, leaves and fruit. Some years later, apparently between 1727 and 1737 a tree was procured and planted in the Botanic Garden, Utrecht. This marked its introduction into Europe during the present era.† As the tree lives to a great age and succeeds under conditions that would be fatal to many species there is every probability that the original tree is still living. Most of the earlier trees raised both in Britain and on the Continent appear to have been males. Wilson‡ says that "in 1790 an English amateur named Blake, sent a *Ginkgo* plant to M. Gaussen de Chapeau-rouge who had a garden at Bourdigny, a village two leagues from Geneva, Switzerland. This tree is historical. It proved to be a female, the discovery being made by Auguste Pyramus De Candolle in 1814. Scions of this tree were distributed over Europe by its discoverer and grafted on

* Journ. Coll. of Science, Japan, vol. viii, pt. 2, 1895 & vol. xii, pt. 2, 1898.

† For an account of Ginkgo in the Jurassic and Tertiary ages *see* A. C. Seward, F.R.S., and Miss J. Gowan, in Ann. of Bot. xiv, pp. 109–154 (1900).

‡ *loc. cit.*, p. 56 (1920).

male trees including those at Vienna and Montpellier." May it not be that grafts were sent at the same time to Utrecht and have been lost sight of until the removal of the elm trees mentioned by Professor Went admitted more light and resulted in the better development of a grafted branch that had hitherto been too weak to flower? In the same way is it certain that male branches have not been grafted upon isolated female trees?

Apart from the interest attached to the fruits or seeds of female trees their decorative value is no greater than that of males whilst the latter are infinitely preferable for public gardens and for gardens attached to residences, owing to the abominable odour of the falling fruit of female trees in autumn. Unfortunately it is not possible to separate the trees before they flower therefore the selection of sex must be left to chance. *Ginkgo biloba* is a tree that might be more extensively employed than at present in schemes of decorative planting for it is very hardy, succeeds under a great variety of conditions, is not susceptible to disease and is rarely attacked by insects. Although the best development is attained by trees growing in a clear atmosphere, good results are obtained in towns, and even under the worst possible conditions of smoke and dust trees live for many years. There is a decrepit specimen growing behind a wall adjoining High Street, Brentford, where for many years it has been hemmed in by high walls and exposed to the dust and dirt of a busy town and constant stream of traffic. Yet it lives on. Well grown trees can be transplanted with safety and specimens 25 feet high have been moved at Kew without difficulty.

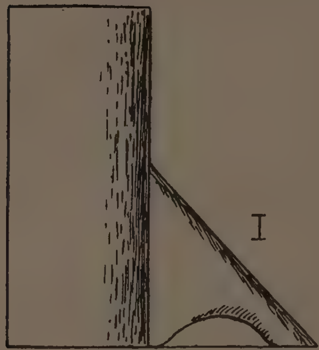
Apart from the value of the edible seeds *Ginkgo* has little economic value, the timber being weak, of no special use, and too scarce to give it any place in commerce.

## XLI.—BUTTRESSES AS AN ASSISTANCE TO IDENTIFICATION.

T. F. Chipp.

It is a little strange that one of the most striking characteristics of trees in the tropical Rain Forests, namely the buttresses, should have received such scant attention. Works on plant geography as a rule give them but a brief notice, forest floras hardly refer to them at all and then only in very general terms, and collectors in their field notes accompanying specimens, rarely record even their presence.

Their function is generally considered to be in assisting to support the massive trunks, and where the subject is dealt with at any length, attention is generally directed to the stilt or prop roots of the Mangrove formation, or to record the huge dimensions of the largest plank buttresses. Mr. H. N. Whitford in his appreciative study of "The Vegetation of the Lamao



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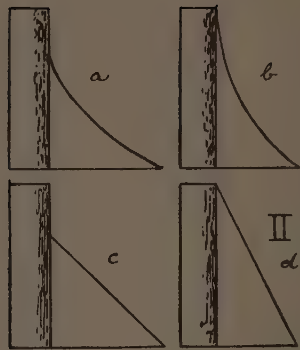


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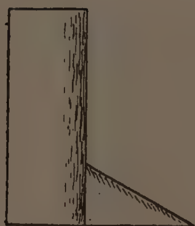

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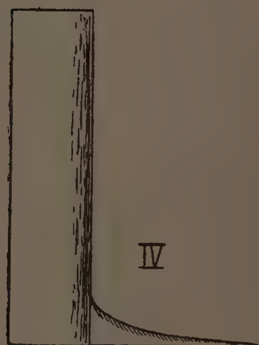

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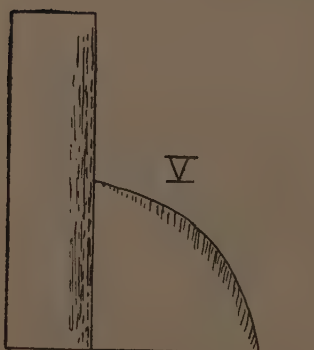

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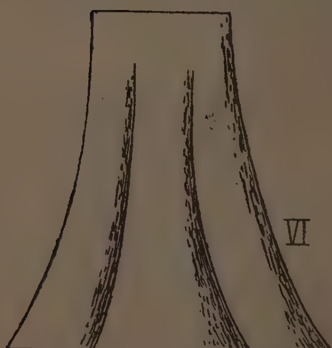

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Forest Reserve " (Phil. Journ. of Sci. I. p. 419) treats the subject more in detail and states that his observations lead him to conclude that buttresses are only developed by trees reaching a dominant position, and thereby enabled to develop wide crowns, and that the extent to which the buttress is developed is in proportion to the spread of the crown.

The majority of trees able to assume dominant positions in the tropical Rain Forests always appear to develop buttresses; and trees that do not attain to such positions do not exhibit any tendency to do so. Whilst normally trees that develop buttresses have no tap roots, information supplied by Dr. F. Foxworthy from his work on *Dracontomelon dao* in the Philippines provides an instance of trees developing buttresses in addition to a marked taproot. As it is usual for the same species and genera to attain dominant positions in the forest, and as the size of the buttresses varies considerably for the same species of tree in different or the same locality, observations were made to see if there was any factor in connection with the buttresses that was more or less constant.

It was found that the presence, absence or the style of the buttress enabled the trees to be considered under four headings.

In the first are grouped those cases of stilt roots or hollow buttresses, where a growth arises some distance above the ground and curves downwards, when it may remain more or less cylindrical (as in the Mangrove and *Ficus* spp.) or a thickening may occur in the upper angle of the root and stem (*Musanga Smithii* P. Beauv.) or this thickening may extend downwards so as to form a more or less complete plank buttress (*Tarrietia utilis* Sprague).

A second group comprises those cases where the buttress is a thickening in the angle formed by the stem and the main roots arising at the collar and spreading laterally along the surface of the ground. Here the buttress is solid and plank-like, as in the majority of the big forest trees.

In a third group no distinct buttress is formed but the bottom part of the stem is grooved or fluted, the folds passing at the base into the main lateral roots.

The four thgroup includes a very few trees of dominant position where the bole is cylindrical to the ground (*Mimusops*).

A further consideration of the specimens that are included in the third group, namely those that exhibit solid, plank buttresses, revealed another point in that the shape of the buttress is constant for the species or genus, regardless of its size.

If the buttress be considered to be a right angled triangle with the right angle at the base of the tree, it will be seen that the side of the triangle representing the height to which the buttress reaches on the tree, bears a definite relation to the base of the triangle, or the length the base of the buttress stretches along the root from the tree. The hypotenuse of the triangle, that is the outside edge of the buttress is straight, concave or convex,

between the highest point of the buttress on the tree and the farthest point of the buttress from the tree on the ground.

The following are examples of observations made in the West African Rain Forests to illustrate this constancy of shape.

Group I.—Trees possessing stilt-roots or buttresses arising in the upper angle of sub-aerial roots, developing imperfectly or rarely perfectly formed plank buttresses :—

*Rhizophora.*
*Avicennia.*
*Ficus spp.*
*Musanga Smithii.*

*Tarrietia utilis* (if buttressed, the height of the buttress equals the length of the base, and the hypotenuse is straight) (Fig. I.).

Group II.—Trees possessing perfectly formed plank buttresses, which arise in the angle of the stem and lateral surface roots :—

a. *Eriodendron.* *Bombax.* — The height of the buttress equals or is double the base and the hypotenuse is straight or concave (Fig. II.).

b. *Piptadenia.* *Parkia.* — The height equals (Fig. II.*c.*) or is half the length of the base and the hypotenuse is straight (Fig. III.).

c. *Entandrophragma.* *Lophira.* — The height is less than half the length of the base, and the hypotenuse is concave (Fig. IV.).

d. *Terminalia.* *Anopyxis.* *Khaya.* *Triplochiton.* — The height equals the base, and the hypotenuse is straight (Fig. II. *c.*).

e. *Cynometra sp.* (Ananta, Twi). — The height equals the base, and the hypotenuse is convex (Fig. V.).

Group III.—Trees with stems deeply furrowed or fluted towards the base but not possessing any real buttresses, (Fig. VI.) :—

*Alstonia congensis.*
*Chlorophora excelsa.*
*Cylicodiscus gabunensis.*

Group IV.—Trees with cylindrical trunks right to the base :—

*Mimusops.*

Further investigation of this subject may provide information of much assistance in the identification of trees in the forest, where only the base can be seen and the crowns are hidden in the tangled canopy above.

# XLII.—ON THE OCCURRENCE OF A SPECIES OF FUSARIUM IN UGANDA.

W. Small.

In a previous communication to the Kew Bulletin,* the present writer described from Uganda a wilt of carnations, *Delphinium*, *Nigella* and *Cosmos* which was shown to be due to a species of *Fusarium*. The same *Fusarium* has been encountered since on other plants, and it is thought that an account of its occurrence may be of some interest. The new host plants include seedlings of the cashew nut (*Anacardium occidentale*, L.), the silky oak (*Grevillea robusta*, A. Cunn.), the rose apple (*Eugenia jambos*, L.), and the loquat (*Eriobotrya japonica*, Lindl.). The attack of the *Fusarium* on the first of these takes the form of a severe wilt disease which is new, so far as the writer is aware, and which is described in some detail in the following pages. The occurrence of the *Fusarium* on the other three hosts is not of the same deadly nature as on the first, but is nevertheless worthy of record and discussion. The fungus has been found also on carnations and *Antirrhinum* associated with *Heterodera radicicola*, Greef. The facts recorded in this paper extend the host range of this fungus which is now provisionally labelled *Fusarium udum*, Butl. There are doubtless numerous unreported cases of the deaths of garden and other plants, and it is probable that so vigorous a fungus and one so difficult to eradicate when established in the soil, is pathogenic to many plants. It has been recorded on only one plant of economic importance in Uganda, the pigeon-pea (*Cajanus .indicus*, Spreng.) and then, not as an original, but as an induced infection, the result of an experiment which is mentioned later. Evidence obtained from soil cultures points to its being able to subsist saprophytically and tide over non-parasitic periods of its life on organic debris in the soil, while it would appear to gain an entrance to the tissues of its host through the smaller roots after the typical manner of the soil-dwelling, semi-saprophytic fungi that cause wilt disease. Various species of *Fusarium* behave in this manner. That the species under discussion should be included among them is supported by the results of the inoculation experiments carried out.

## Symptoms of the Wilt Disease of Cashew Nut.

The writer's attention was drawn to the cashew nut wilt in April 1921 by the officer in charge of the Government Plantation, Kampala, who pointed out that a large number of cashew nut seedlings was dying off in the nursery. A cursory glance at a bed of seedlings was sufficient to show that the percentage of affected plants was very high, and subsequent observations in several groups of plants showed as much as 100 per cent. There seemed to be no case of recovery from an attack of the fungus.

* *Kew Bulletin*, 1920, p. 321.

The diseased plants had been grown from seed and had not been disturbed in any way.

The most characteristic symptom of the disease under discussion was the softening of the hypocotyls of the attacked seedlings, the tissues of which were, in cases, so completely disorganised that they collapsed under easy pressure or broke when a pull was exerted to remove the diseased plant from the soil. This condition was analogous to that found in carnations affected with the same wilt disease and it doubtless gave rise to the alternative name "crown-rot," which has been used by van der Bijl in South Africa.* It likewise led the writer to presume the cause of the disease to be similar to, if not the same as, that of the carnation wilt, viz., a species of *Fusarium*, although at the moment no *Fusarium* mycelium or conidia such as were found externally on wilted carnation plants could be found on the diseased plants under examination. The leaves of affected plants withered and fell off. Owing to the breaking down of the cortical tissues, the roots, especially the smaller, were usually soft to the touch. While the lower part of the hypocotyl might be rotten, the upper portion of it might be quite firm. Microscopic examination of sections of the latter showed the cells of the parenchyma to be unaltered and full of starch, while sections of the firmer parts of the former showed the presence of mycelium in quantity. Good preparations were obtained from both hypocotyls and roots by staining with haematoxylin and alcoholic eosin, as recommended by E. J. Durand,† after killing in Durand's modified Gilson's mercuric chloride solution and clearing away the usual brown discolouration in a saturated aqueous solution of chloral hydrate. Hyphae were found in the bundles of the roots, but their choking of the vessels was never complete enough to account for the wilting and death of the plants. In fact, they were always much more plentiful in the root cortex and in the starch cells of the parenchymatous tissues of the hypocotyl. At times the body of a cell of the latter would appear to be a tangled mass of hypae. The hyphae resembled very markedly those found in sections of wilted carnations and described as follows‡ by the writer—"This internal mycelium varied in thickness, was much branched, and was seen to pass freely from tracheids to parenchyma without constrictions. The main hyphae in a tracheid would give off numerous slender branches which could be followed as they penetrated the pits." Where hyphae were present, no cell-contents or stored material such as starch could be seen, and it is conceivable that the effects of the fungus are more of an organic character leading to starvation or of a toxic character leading to poisoning than of a physical character leading to a mechanical choking of the ducts. A certain amount of blackening of diseased root or hypocotylar

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* Ann. Appd. Biology, ii, 267, 1915–16.
† Phytopathology, 1. 120. 1911.
‡ *loc. cit.*, p. 321.

tissues in the form of streaks was always present, but it was difficult, owing to the general brown colour of diseased parts, to trace the streaks from one part of the plant to another. Only chlamydospores were seen within the tissues.

As already mentioned, none of the plants collected for laboratory study showed any external mycelium, but a few seeds which had not germinated were taken with fungi *in situ* from affected beds. These seeds were rotted by moulds, and one species each of *Nectria* and *Pestalozzia*, the latter near to *P. palmarum*, Cke., was present upon them. On only one or two seeds, mycelium accompanied by microconidia which recalled strongly those of the carnation *Fusarium* was found. It seemed possible that the germination of those seeds had been prevented by attacks of the *Fusarium* in the soil of the beds, but whether this was definitely so could not be determined. The few seeds obtained were so permeated by moulds that sterilisation had to be thoroughly done, so thoroughly that, in every case, whatever living organisms may have been within were killed.

## Isolation of the Cashew Nut Fusarium and its growth in Pure Culture.

Fresh material when surface-sterilised by careful washings in successive portions of rain water, distilled water, and mercuric chloride solution (1 : 1000), and placed in a moist atmosphere, showed plentiful typical mycelium in tufts of a honey-yellow, white, or pale-pink colour after two or more days. The mycelium frequently took the form of coremial strands. Those plants of which the hypocotyls were in a collapsed, soft, and watery condition gave the best results. The first mycelial tuft invariably appeared at the base of the hypocotyl, and it bore a few microconidia after about five days (Fig. 1).

Fig. 1. Typical microconidia from damp-chamber material (cashew nut), $\times$ 500.

Microconidia were plentiful in, as a rule, seven or eight days. Meanwhile, other tufts on the hypocotyl and roots grew rapidly, bore microconidia, and coalesced to form a whitish aerial mycelium covering the whole hypocotyl and roots in about eighteen days. Before this stage, macroconidia, measuring up to 27 by $2 \cdot 5\mu$ and mostly three-septate, had been easily found.

Tissue-fragments removed under sterile conditions from hypocotyls and roots were placed in prune decoction in petri

dishes after being dipped in alcohol and flamed. It was found that a growth of hyphae resembling that just described was visible in four days, that the mycelium took on a definite white or pink shade in five or six days and bore numerous microconidia in nine days. The honey-yellow colour was visible in parts of the mycelium in eleven days, and macroconidia were found in quantity in eighteen days. In several cases, chlamydospore-formation took place in six or seven days. It was thus easy to obtain inoculum for pure cultures.

The first pure cultures were made on banana plugs in sterile Roux tubes; the inoculum consisted of microconidia from the tissue-fragment cultures mentioned above. No mycelial growth was visible under four days, and it was then very sparse and white in colour. Microconidia were produced in eight days and became very numerous later, but no macroconidia or chlamydospores were seen. On slants of prune agar of 25° acidity in Fuller's scale, white or pink-white aerial mycelium covered the whole surfaces of the media in three days and microconidia were then very plentiful. They were to be found particularly in moist oily superficial streaks resembling the growth of bacteria. Macroconidia (Fig. 2) were found a little later, and chlamydospores were numerous in twelve days.

Fig. 2. Macroconidia from prune agar culture (cashew nut), × 500.

After two months and more, the surfaces of the slants were masses of macroconidia in an apparently moist condition and of a yellow tinge, and after ten months they still kept that condition. The conidia were then capable of germinating rapidly overnight in a hanging-drop of distilled water. In prune agar plates, the growth and development were similar except that the mycelium became dark-grey in colour in parts.

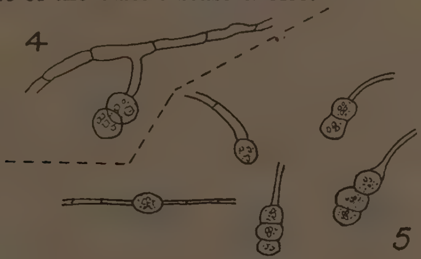
On glucose meat-extract agar of 30° acidity, growth was visible in twenty-four hours, and microconidia in forty-eight. The aerial mycelium was white and small in amount. After six days, the conidia were septate, and measured up to $38\mu$ long; in twenty days they were very numerous and four or five-septate. Chlamydospores were formed in twenty days, and, after that, the mycelium became dark in colour and apparently brittle, as if it were breaking up into resting portions.

In French-bean agar of 20° acidity, the aerial mycelial growth was similar to that above, but larger and inclined towards a

star-shaped flocculent habit such as was found on whole plants in the damp. Three-septate conidia were found after six days. They measured up to $35\mu$ in length, and were in proportion broader than those of the glucose meat-extract culture above or of the rice agar culture below. Chlamydospores were formed in thirteen days, and a few days later were darker in colour than at first, of an average diameter of $10\mu$ (Fig. 3), and evidently mature.

Fig. 3. Mature chlamydospore from French-bean agar culture (cashew nut), × 500.

In rice agar of 15° acidity, the aerial white mycelium bore microconidia in two days. Moist streaks were then quite apparent. In three days three-septate conidia were common, and in six days chlamydospores were very numerous. Later, the terminal chlamydospores were found to be in many cases two-celled (Fig. 4), and even three-celled (Fig. 5), in which case the aggregation resembled a spore of *Piricularia oryzae*, Br. and Cav., the cause of the blast disease of rice.



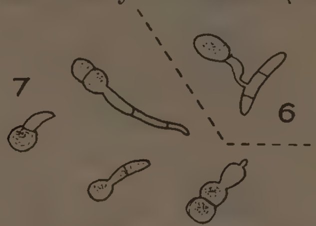

Figs. 4–5. Chlamydospore-formation in a rice agar culture (cashew nut), × 500.

These chlamydospores were found while conidial production was still in progress. Meanwhile, the aerial growth of mycelium arranged itself along definite concentric rings, and the conidia became so numerous that they covered the surface of the medium as in the prune agar slants mentioned. The largest measured $32\mu$ long. The chlamydospores when placed in hanging drops germinated in forty-eight hours to give mycelium which produced further chlamydospores, terminal and intercalar and small, for they measured only up to $5\mu$ in diameter, or directly to produce microconidia (Fig. 6), the latter condition being the more common. The contents of the chlamydospores were coloured brown when treated with two per cent. osmic acid, while mycelium and conidia were unaffected. The mycelium in all the above cultures was typically that shown by van der Bijl in the plates attached to his paper.*

After six months and longer, the above cultures which had been kept in the meantime at laboratory temperature (an average

* *loc., cit.*, plates 37–40.

of about 25° Centigrade), as indeed all the cultures were kept, were found to be in a moist condition. No perithecial formation was noted, but minute brownish aggregations of hyphae occurred over the surfaces of the media, more particularly in the case of the glucose meat-extract agar. In all the agar cultures, there were also the distinct surface lines of growth which resembled in a striking manner the growth of bacteria. These lines which radiated in all directions were now composed of germinating chlamydospores, micro- and macroconidia. The microconidia were always far more numerous than the larger conidia. Chlamydospores, especially when formed intercalarly, were numerous in all the old cultures, and frequently occurred in groups of three or more; their walls averaged $1 \cdot 5\mu$ in thickness No separation had taken place between the component parts of the two-celled terminal chlamydospores and their germination was observed to result in only one filament (Fig. 7).




Figs. 6–7. Germination of chlamydospores, 48 hours (cashew nut), × 500.

The *Fusarium* was also grown with success on the sterilised surfaces of cashew nut seedling hypocotyls split longitudinally and carefully steamed. These cultures were kept in moist petri dishes. The behaviour of the fungus was in all respects similar to that in the agar cultures except that the chlamydospore form was not found. In one case, the mycelium assumed a pale blue colour with white edge, as if alkali had been added by accident to part of the surface of the medium. The blue colouration eventually gave place to honey-yellow, the prevailing colour in these cultures, although the white-pink colouration was by no means wanting.

Attempts were made to grow the fungus in sterilised soil moistened with sterile distilled water. Small quantities of the soil convenient for examination were placed in petri dishes and inoculated with conidia and mycelium from the agar cultures. Similar cultures were instituted with unsterilised soil from a locality presumably free from the *Fusarium* wilt. No success was met with until the cultures were incubated at 30° C, when fungus hyphae were found spreading in all directions from the points of inoculation. Characteristic mycelium and microconidia of the *Fusarium* were also found on organic fragments in the soil of the cultures. No other spore stage of the fungus was seen. The unsterilised soil cultures were much more successful than the others.

In conidial germination in hanging-drops, the septa might disappear, and the hyaline, granular, septate germ-filaments might be visible after only one or two hours. They took their origin most often from the end cells of the conidia, sometimes from one only, frequently from both, and they branched early, were attenuated, and ramified in all directions, or remained short and thick, resembling and forming secondary conidia (fig. 8).

Fig. 8. Germination of macroconidia in hanging-drops (cashew nut), × 500.

Microconidia were produced terminally from long and from short filaments. Anastomosis between neighbouring filaments took place readily, and the drying-up of the hanging drop was a signal for the immediate formation of chlamydospores.

On the whole, cultural evidences pointed strongly to the identity of the previous *Fusarium* from carnation, *Nigella*, &c., with the later *Fusarium* from cashew nut, although mycelial colourings in the cultures of the latter did not seem to be so strongly marked as in the cultures of the former. There could be no denial of the likeness between the actual mycelia, conidia, chlamydospores, and the methods of conidial formation. The first-produced microconidia invariably reminded the writer of the numerous microconidia to be found in his previous cultures of the carnation strain of the *Fusarium*, and the macroconidia recalled the previous *Nigella* strain. In other words, it seemed as if the *Fusarium* from cashew nut was showing in itself the spore-characters of all three previous strains from carnation, *Delphinium* and *Nigella*—characters which seemed at the time to be sufficiently constant to be regarded as the physiological expression of each strain.* The strains, however, were not biologically distinct because no one of the three was selective in the choice of its host, all being equally pathogenic to the hosts of the others, and it was not surprising that a new strain of the *Fusarium* should show a combination of the characters of the previous three, especially when it proved to be pathogenic to one at least of the previous hosts. Moreover, it was found that a single strain might vary within itself in its degree of conidial-production.

* *loc. cit.*, p. 325.

### Infection experiments with cashew nut plants.

The effects of the disease had been so disastrous that only eight plants were available for inoculation experiments. The experiments were therefore less numerous than were wished. The plants were healthy seedlings about ten inches high with two pairs of leaves and all were in pots. The inoculum in all cases was drawn from the prune agar slant cultures for the reason that the conidia of those cultures germinated in water more vigorously than the conidia of the others. A suspension of spores in sterile distilled water was used, and the viability of the spores was tested in the same medium. After necessary wounds had been made and the inoculum placed in position, disturbed tissues were carefully replaced. All the plants were placed out-of-doors after a day in the laboratory.

The inoculum was placed in contact with lateral and tap roots of one plant, in wounds on a tap root and lateral roots of another, in contact with a hypocotyl under the soil level and in a wound in a hypocotyl under the soil level. It was also placed in the soil one half inch from roots, and one half inch from a hypocotyl. Two plants were kept as controls, and they remained healthy throughout the experiments.

In the cases of the plants the roots of which, both lateral and main, were treated, in one case unwounded and in the other wounded, leaf-wilting began in five days and after ten days both plants had collapsed. The hypocotyls of both were then soft and watery. After three more days, both plants were dug up, carefully sterilised, and placed in moist chambers. It was noted that, in the case of the unwounded plant, the smaller lateral roots had decayed while the tap-root was still healthy and firm, and that, in the case of the wounded tap-root, the tissues had collapsed. On the surface of the soil of the pot of the unwounded plant, *Fusarium* mycelium and typical microconidia up to $10\mu$ long were found. After only twenty-four hours in the damp, both plants showed mycelium on the hypocotyls with numerous microconidia. Three- to five-septate macroconidia up to $60\mu$ (fig. 9) and chlamydospores then appeared, and four days later seven-septate conidia (fig. 10) were in abundance. These large multi-septate


Figs. 9–10. Large macroconidia from an inoculated plant (cashew nut), $\times 500$.

conidia were not found in any of the cultures of the *Fusarium* isolated from cashew nut material, but they were noted previously in cultures of the fungus from *Delphinium* and *Nigella*.* They seemed to be produced only sparingly. After another fourteen days, *Fusarium* mycelial cushions bearing conidia were found at the leaf-scars of the stem. That the fungus progressed upwards through the tissues of the plants was proved by the examination of series of sections. Hyphae were found throughout in great abundance. It was rather remarkable that both plants should behave in an exactly similar manner despite the fact that contact between hosts and the parasite had been brought about in different ways.

The plant which had been treated by placing the inoculum against the hypocotyl remained healthy and showed no signs of disease, but the plant with the wounded hypocotyl behaved in the manner detailed above for the root-treated plants even to the appearance of mycelium and conidia at the leaf-scars. The time development of the various stages corresponded to a day.

The two remaining plants, *i.e.*, those with the inoculum placed within half an inch of roots and hypocotyl respectively, did not contract the disease although the former might have been expected to do so. Neither of them was as robust as the control plants, but neither developed the *Fusarium* in the damp chamber and in neither could the presence of hyphae in the tissues be demonstrated. It is possible that they might have proved to be diseased had they been left longer in the pots. Likewise, at a later period, one of the control plants appeared to be sickening, but a careful examination of it failed to disclose the particular symptoms of the wilt disease or the presence of a parasitic fungus.

From the above experiments, it was concluded that, the *Fusarium*, a soil fungus, was capable of invading the smaller roots of young cashew nut plants with or without the help of a wound and the tap-root through a wound, and of causing death. It seemed, however, that the unwounded hypocotyl of the cashew nut seedling was impervious to the advance of the fungus—a statement that may stand further tests, if such were made, since the *Fusarium* is essentially a root parasite. Unfortunately the infection experiments were too few to justify sweeping deductions, although one has been made, but further work may be expected to strengthen the conclusion drawn with regard to liability to root-infection, for it is strongly supported by evidence from wilt diseases of other plants caused by soil fungi and by the evidence previously obtained from the study of the *Fusarium* on carnations, &c., and afterwards obtained from the *Fusarium* on *Grevillea*.

## Cross-inoculation tests with the cashew nut Fusarium.

In view of the morphological resemblances between the *Fusarium* isolated from the carnation, *Delphinium*, *Nigella* and

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* *loc. cit.*, p. 325.

*Cosmos* wilt and that from the cashew nut, it was thought advisable to carry out a cross-inoculation experiment in order to test the pathogenicity of the cashew nut *Fusarium* with regard to one at least of the plants involved in the previous investigation into the wilt of carnation, *Delphinium*, *Nigella* and *Cosmos*. A large pot of healthy larkspur (*Delphinium*) seedlings happened to be available and it was therefore employed. The seedlings growing along two diameters of the pot taken at right angles to each other were so removed as to leave the remainder in four distinct groups. Each group occupied a quadrant of the soil surface, and each was separated from its neighbours by a line under one inch broad. Two opposite groups of plants were kept as controls, and the two remaining groups were treated by watering the soil, which had been carefully broken up, with, in one case, a suspension of conidia from a prune agar culture in distilled water and, in the other, a similar suspension of spores from a rice agar culture. No special effort was made to bring the inoculum into contact with the roots of the seedlings and no wounding took place. The soil of the control areas was also broken up. After inoculation the soil of the whole pot was gently kneaded into its former state. The viability of the conidia had been previously tested in hanging-drops. The results of this experiment were striking. Plants in both inoculated areas began to wilt on the sixth day and the great majority of them were dead in twenty-three days. Meanwhile, after twenty days, plants in both the control areas of the pot began to show signs of disease, and a further period of ten days proved fatal to practically all of them. Typical samples of dead or dying seedlings were taken at intervals from inoculated and control groups and were placed in a moist atmosphere after careful sterilisation. From all without exception, the *Fusarium* was recovered with mycelium and conidia resembling in all respects those obtained from the cashew nut *Fusarium* cultures. The wilted seedlings showed under the surface of the soil the blackened, soft and sunken area of stem typical of the previous wilt disease. This experiment provided further evidence, if such was required, of the virulent root-parasitism of the *Fusarium* and it might have been taken to show the rapidity with which the fungus could spread across a bridge of soil. But, in this connection, it should be remembered that the plants were fairly crowded in the pot and that there was opportunity for the fungus to spread from root to root. That it did so was shown by the general decay of the smaller roots of both inoculated and control plants.

At the same time, young mango plants, chosen because of their affinity to the cashew nut, were experimented with. the plants were healthy seedlings of eight to ten inches high and were in pots. Conidia from prune agar cultures were used. Masses of them were transferred to sterile distilled water in a watch-glass

and broken up to form the inoculum. The conidia were shown to germinate freely overnight in hanging drops of the same medium. During the experiment, the mango plants were kept out-of-doors.

A few c.c.'s of the spore suspension were placed by means of a sterile pipette among the soil around the smaller roots of one plant and in contact with the unwounded lateral roots of another. Two plants were inoculated in wounds in the tap-roots made by scraping with a sterile scalpel, and other two were similarly inoculated in the hypocotyls. Two control plants were wounded one in the roots, both lateral and main, and the other in the hypocotyl. After nine months, only one plant, one of the two inoculated in a tap-root wound, had shown symptoms of disease. The other plants, including the controls, were perfectly healthy and had thrown out pairs of new leaves. The diseased plant appeared to be dead ten days after wilting had commenced, and the *Fusarium* was recovered from its roots. The injured mango, therefore, could not be said to be immune to attacks of the soil *Fusarium*, but it was apparently much less susceptible than the cashew nut. This was not altogether surprising, for mango seedlings had been grown in beds adjacent to those from which the diseased cashew nut seedlings were taken, and they had not yet been found diseased. It was unlikely that the *Fusarium* was confined to only a few beds in a nursery of many similar beds separated from each other by narrow paths and containing many species of plants both economic and ornamental. It was, indeed, more than likely that these plants were immune for the time, or only slightly susceptible, as was the mango, to the *Fusarium* wilt disease. The general health of the seedlings was a factor of importance in the continuance of the immunity of the plant, and seedlings disturbed by, say, the operation of transplanting might prove susceptible, expecially if they were subjected to root-pruning. Evidence bearing on this point is given under a later heading.

Another species of plant belonging to the *Anacardiaceae*, *Spondias lutea*, L., the yellow mombin, was tested. Seedlings were inoculated in root wounds with the cashew nut *Fusarium* and, at a later date, others were treated similarly with a strain of the *Fusarium* isolated from wilted *Grevillea robusta* seedlings. The *Grevillea* strain did not prove to be pathogenic, but, in the case of the other, wilting began in five days and the plants were dead in eleven days. The *Fusarium* was recovered by the former methods. The growth in culture was typical of previous growths and, in addition, remarkable for the production of a thick-set three-septate spore (Fig. 11) with stouter walls than usual which recalled the spore-production of the *Nigella* strain of the *Fusarium*, and for the presence of the rather scarce seven-septate conidium. On the damp-chamber material of *Spondias*, the three-septate spore was commonly associated with the

*Fusarium*, and an unusual development of chlamydospores was found (Fig. 11) after twenty days.

Fig. 11. Conidia and chlamydospores of the *Fusarium* recovered from *Spondias lutea* after inoculation with the cashew nut strain, × 500.

The chlamydospores were of typical size and took origin from any conidium. In fact, the fungus seemed to be passing into a resting stage for the hyphae also broke up into thick-walled portions and chlamydospores.

## Control measures.

A direct attack on the *Fusarium* or, indeed, on any soil-inhabiting and wilt-producing *Fusarium*, appears to hold out little hope of success, as witness the efforts made with regard to cotton wilt in U.S.A. There is, unfortunately, no progress to report from the experiments carried out in Uganda. It was mentioned in the carnation wilt paper cited that treatment consisting of a soaking with a solution of carbolic acid (one ounce to one gallon of water) at the rate of one gallon of solution to every four or five square feet was not successful in killing off the *Fusarium*, and it was indicated that the soil-fungicide *Fungal* which liberates formalin might be of greater avail. Van der Bijl in South Africa had no positive results when endeavouring to free soil of the same *Fusarium*, the cause of a carnation wilt, by the use of two-hundred gallons per acre of one per cent. formalin, but injections of formalin were proved to destroy the fungus of a carnation wilt disease, *Fusarium dianthi*, Pril. and Del., in France.

It was decided to experiment with *Fungal* and *Izal*. A drop of a five per cent. solution of the latter in a culture was found to

inhibit all growth of the *Fusarium*. Again, the viability of the conidia of the agar cultures in the presence of formalin vapour was tested in hanging-drops. Controls were set up and they showed that the macroconidia of all four agar cultures, especially those from the prune agar slants, germinated vigorously overnight in distilled water drops. Similar sets of conidia were placed in distilled water drops over two per cent. and four per cent. formalin, and no germination resulted in any of them. The spores became shrunken in appearance, and, after only twenty-four hours' exposure to the formalin vapour, refused to germinate when water was substituted for the formalin. The effect of formalin vapour on growing mycelium was also tested in hanging-drop cultures and found to be total inhibition of growth and spore-production followed by death.

Experiments commenced with soil fungicides were, owing to the seeds being too old, unproductive of results. In any case, it should be mentioned that the expense of using in large quantities a proprietary article like *Fungal* would be prohibitive in Uganda. It is possible that the only ordinary means of combating the *Fusarium* will be found in continued deep cultivation which might succeed in eliminating all the points of origin of the *Fusarium*. Steam sterilisation of infected soil might also be employed, but it is impracticable in the majority of cases, and a study of such factors as time of planting, water supply and soil texture has not been possible.

## The Fusarium on Grevillea robusta seedlings.

Subsequent to the discovery of the cashew nut wilt, attention was drawn to a destructive wilt of *Grevillea robusta* seedlings in adjacent beds. The seedlings were twelve inches or more in height and, unlike the cashew nut seedlings, all had been transplanted. On the above-ground parts there was nothing of particular note, and the typical soft and sunken area present in the cases of the carnation and cashew nut was absent from the hard woody *Grevillea* stems. Many of the smaller lateral roots were altogether decayed or denuded of bark and cortical tissues, while the tap-roots were still comparatively firm. A histological examination, however, of pieces of tap-root showed that they were permeated by the fungus, for hyphae, microconidia, and chlamydospores were present in the tissues. As in the case of the cashew nut, mycelium was not found in quantity sufficient to choke the elements of the vascular system. In fact, it was far more plentiful in the ground tissue. It resembled the internal mycelium of the cashew nut and carnation. Conidia were much less numerous than chlamydospores, and their connection with the hyphae was less plainly seen. The chlamydospores occurred singly or in the usual small groups, and were also more numerous in the parenchyma cells than elsewhere. Their average diameter was 6–7$\mu$ and they were therefore smaller than those of the *Fusarium* in culture, but examples of full size were not wanting.

Isolation methods similar to those already described were followed. Whole plants as well as lengths of main and lateral roots were sterilised and placed in damp chambers. They yielded only the *Fusarium* in the form of the white, flocculent mycelial cushions showing coremial strand formation and bearing at first typical microconidia and afterwards macroconidia up to 53 by 5$\mu$. The fungus occurred in this form on all parts of lateral and tap-roots but never on the stems. Several root tissue-fragment cultures were set up in prune agar, and they showed only the one fungus, the same *Fusarium*, originating from the fragments that proved fertile. The material obtained in both the ways mentioned was used to institute sub-cultures on the mediae previously employed in the study of the cashew nut wilt fungus, and the colour-, mycelial-, and spore-development was typical of former cultures. Growth occurred in concentric rings in one case and coremial strand formation was commoner in this strain of the *Fusarium* than in any other. White, pink and honey yellow were the predominant colourings. In one glucose meat extract tube culture and one prune agar plate, the mycelium in the medium was of a pale blue colour recalling that found in one of the cashew nut hypocotyl growths. This blue colour persisted although it became less and less distinct. The chlamydospores were single or double while terminal, and single or in the usual small groups while intercalar, and they germinated in the same manner as those of the cashew nut *Fusarium*. There was, therefore, no doubt of the identity of the fungus attacking the *Grevillea* seedlings.

### Infection and control experiments with the Fusarium from Grevillea.

The conditions under which infection had taken place differed from those holding in the case of the cashew nut seedlings inasmuch as the *Grevillea* plants had been transplanted and root-pruned during the operation while the cashew nut seedlings had been undisturbed. On this account, it was decided to combine a control and infection experiment. Two affected beds were cleared of ail *Grevillea* plants, carefully dug over and treated as formerly, except that only one, the weaker, strength of *Fungal* was applied. A fortnight afterwards, one row of *Grevillea* seeds was sown lengthways in each bed so as to traverse the treated and the control halves of the bed, and a second line consisting of transplants was laid out parallel to the seeds. Alternate transplants in the treated halves of both beds were root-pruned, while all the plants in the control half of the *Izal*-treated bed were root-pruned and none of those in the corresponding half of the *Fungal*-treated bed were root-pruned.

After a few weeks, both rows of seeds had germinated, and at the end of ten weeks the resulting plants were well grown and healthy. They remained so at the end of six months, and there is no difference to be noted between the sets of seedlings growing

in the control and treated halves of the beds. The transplants, however, provided striking results after ten weeks, inasmuch as it was apparent that the root-pruned plants were dead and dying in a distinctly greater degree than the non-root-pruned plants. In the control half of the *Izal*-treated bed where all the transplants had been root-pruned, all the plants were dead, and in the treated halves of both beds the root-pruned plants were long dead while the alternate non-root-pruned plants were only sickening. The non-root-pruned plants in the control area of the *Fungal* treated bed were in the same condition as the non-root-pruned plants of the treated areas. Representative plants were taken for examination, and the *Fusarium* was recovered from all. Sections of roots showed no differences from previous preparations. There was no distinction in kind or degree of disease between plants from the treated and control areas. It was concluded, therefore, that the *Izal* and *Fungal* treatments were quite ineffective and that a set back to the *Grevillea* seedlings in the form of transplanting operations was sufficient to ensure a parasitism of the *Fusarium* which varied in virulence according to the treatment of the plants, for the addition of root-pruning to transplanting ensured one hundred per cent. deaths. A series of cross inoculation experiments with the *Fusarium* from cashew nut, *Grevillea* and loquat is described below.

### The Fusarium on Eugenia jambos seedlings.

A bed adjoining the two *Grevillea* beds referred to above had been filled with transplanted rose apple seedlings in rows, and it was found that they also were dying off in time. The number of deaths was never more than a small percentage of the number of plants, whereas in the *Grevillea* beds the deaths approached one hundred per cent. The symptoms of disease were exactly similar to those found in the *Grevillea* seedlings, and micro-preparations showed a like infestation of hyphae. No conidia were seen within the tissues and chlamydospores were scarce. In one plant, the epidermal tissues of the tap root had been invaded by the mycelium of *Botryodiplodia theobromae*, Pat. Damp chamber treatment was slow but successful in causing the development of the *Fusarium*, and root-fragments in culture media were fertile of *Fusarium* in nine out of ten cases. It seemed, therefore, that here was another case of the parasitism of the *Fusarium* but in a further reduced form. The *Eugenia* seedlings had been root pruned and were on that account more open to the entrance of the *Fusarium* into the roots, but the number of cases of attack was small. This species apparently possessed an immunity denied to the silky oak and the cashew nut.

### The Fusarium on seedlings of Eriobotrya japonica.

At the same time, a few seedlings of loquat in a near by bed were observed to wilt. They also had been transplanted,

but they were on the whole strong and vigorous plants. The wilt was accompanied by a symptom of the carnation and cashew nut disease, viz., the softening of the area of stem immediately below ground level. The tap-root was firm while some of the smaller roots were decayed. Hyphae were found in the root tissues as formerly, but neither conidia nor chlamydospores were seen. Pure cultures of the *Fusarium* were prepared from damp-chamber and tissue-fragment material. The lack of colour and of a large aerial mycelium in the cultures and the rapid development of the oily streaks and of conidia were striking. The aerial mycelium was small in amount and almost colourless, while three-septate macroconidia were very numerous in three days, as in the case of the cashew nut strain of the *Fusarium* grown on rice agar. Later, five-septate conidia were found in great numbers, and a three-septate sturdy spore resembling that found in the case of *Spondias lutea* inoculated with the cashew nut *Fusarium* was also common.

### Further cross-inoculation experiments.

Further experiments were conducted with seedlings of silky oak, rose apple and loquat. All were healthy potted plants and were kept entirely out-of-doors. Each host was inoculated with the *Fusarium* from *Grevillea*, loquat and cashew nut. A suspension of tested conidia in sterile distilled water was used and all the plants were wounded in the larger roots before inoculation. There were three sets of each host plant and the necessary controls.

Positive results were obtained only in the case of the *Grevillea* plants, and all the rose apple and loquat seedlings remained perfectly healthy and continued their growth. The *Grevillea* plants proved susceptible to all three strains of the *Fusarium* used in inoculation, and the fungus was recovered from the dead plants with typical mycelium and conidia. The results seemed to confirm what has been apparent with regard to the degree of susceptibility of the various hosts, viz., that it varied with the host plant concerned, *Grevillea* being the most susceptible. It is to be noted that even the cashew nut strain with the help of a wound-entrance into the tissues did not prove harmful to the rose apple and loquat hosts and that these plants could be classed with the mango as regards power of resistance to the *Fusarium*. If a scale of susceptibility were to be drawn up, the cashew nut would occupy a high place in it, the loquat and rose apple allow-one, and the silky oak an intermediate position.

### The Fusarium associated with Heterodera radicicola, Greef.

The afore-mentioned occurrences of the *Fusarium* were all from one area. Its association with the well-known eelworm, *Heterodera radicicola*, occurred on several *Antirrhinum* and carnation plants growing in a bed and in tubs of soil in a private

garden well-removed from the other locality. The eelworm had attacked and caused the deaths of the *Antirrhinum* plants and the usual galls were present in the roots. There was no softening of the stem such as would be induced by the *Fusarium* wilt, and although mycelium was found in the affected soil and on the small lateral roots behind or in front of the *Heterodera* galls and shown to be in both cases that of the *Fusarium*, there were no hyphae in the tissues of the plants except in the galls and the smaller roots mentioned. The external mycelium was white and accompanied by microconidia on the small roots, and it passed from one root to another in strands strong enough to hold together particles of soil. When grown in culture it was typical of former growths. In one case, the soil mycelium gave rise in culture to two fungi, the *Fusarium* and *Sclerotium Rolfsii*, Sacc., the latter of which had been found associated externally with the carnation wilt in 1919,* but no *S. Rolfsii* was derived from any tissue-fragment culture. The presence of hyphae in the galls was demonstrated by sections, and their connection with the *Fusarium* was shown by inoculating the media previously used and also potato-dextrose agar with fragments of galls teased out in sterile distilled water. The *Fusarium* was obtained also from fragments of roots cut from near the galls. In the case, therefore, of the *Antirrhinum* plants, it was concluded that the *Fusarium* was introduced directly or indirectly into the galls and thus indirectly into the root tissues by *Heterodera* and that there was no evidence of its being truly parasitic on the plants. Adjacent plants were not attacked either by fungus or nematode. The case of the carnations was somewhat different, for, while they showed all the symptoms of *Fusarium* attack, there were no galls on the roots. The eelworms were confined to the crown-rot area of the stem and to the collapsed tissues of the smaller roots. Carnations which had not been attacked by the *Fusarium* were not attacked by the eelworms. Nematode root-galls frequently contain a species of fungus, and it was not surprising to find in the fungus a known soil-dweller and one capable of being destructively or weakly parasitic. The relationship between *Heterodera* and the *Fusarium* was in all probability an accidental one arising solely from the proximity of the one organism to the other, and leading, in the case of the *Antirrhinum*, to a degree of parasitism so feeble that it was only just removed from saprophytism. The case of the carnations, again, revealed the *Heterodera* as a mere agent in the destruction originated by the *Fusarium*. At a later date, galls formed on the roots of *Thunbergia erecta*, J. Anders. by *Heterodera radicicola* were examined for the presence of the *Fusarium* with entirely negative results.

## Identity of the Fusarium.

During the progress of the work recorded in the foregoing pages, the writer had been struck with resemblances, details of

* *loc. cit.*, p. 327.

which have not yet been given, between the *Fusarium* under study and that described as *Fusarium udum* by Butler on pigeon-pea in India.* The question of the identity of the *Fusarium* with one of the species separated out and described in recent years in America or with *F. dianthi*, Pril. and Del.,† the cause of a carnation disease in France, was attended with many difficulties but was not overlooked. With regard to the former, the *Fusarium* seemed to be nearest to *Fusarium radicicola*, Wollenw., the cause of a tuber-rot of potatoes,‡ and to differ from the latter in having a *Cephalosporium* stage in place of the *Cylindrophora* of Delacroix as well as in other details. Delacroix's suggestion that *F. dianthi* was carried by nematodes is of interest in view of what is recorded under a previous heading. There did not seem, however, to be any sufficient reason for going further afield than *F. udum*, a species which was set up to obviate such a position as that in which the writer found himself when confronted with the task of naming the *Fusarium*. Efforts had already been made to induce the formation of the perfect stage of the *Fusarium*, both as it occurred previously on carnations and other plants and latterly on cashew-nut seedlings, by damping the cultures and growing the fungus on steamed cashew-nut twigs and seeds, of which several were kept out-of-doors under natural conditions, but they had met with no success. The only perithecial formation found at any time was the *Nectria* on rotted cashew-nut seeds, and it was shown to have a *Fusarium* differing entirely from *F. udum*. Moreover, other forms, species of *Botryosphaeria*, *Dothiorella* and *Phomopsis*, have been found on wilted *Grevillea* seedlings left standing on the soil after death, but no evidence that any connection exists between either of them and the *Fusarium* has been derived from the culture work carried out.

The identification of the *Fusarium* being called for on grounds of convenience alone, it was therefore necessary to rely on cultural and morphological characters, and it was thought advisable to repeat some at least of Butler's cultural experiments; and also to attempt the inoculation of pigeon-pea, its host in India, to show whether or not the Uganda *Fusarium* was identical with *Fusarium udum*. Liquid and solid media prepared, as under, according to Butler's directions were inoculated with spores of the cashew nut strain from the agar cultures which had provided inoculum for the infection experiments. The standard solution for the liquid media consisted of ammonium nitrate 5 gr., potassium phosphate 2·5 gr., and magnesium sulphate 1·25 gr. in 500 cc. distilled water, and the substances mentioned below were added to flasks containing each 30 cc. of the standard solution. Notes on the cultures are appended to each.

* Memoirs of the Dept. of Agric. in India: Bot. Series 2. No. 9, 1910.

† G. Delacroix, Annales de l'Institut National Agronomique, 16, 1901.

‡ Jour. Agric. Res. 2, 4, 257, 15 July 1914.

Liquid media :—

1. Standard solution + 3 % glucose.—The best growth of all the liquid cultures took place in this medium. The medium was entirely filled, and in eight days the culture was of a pale-pink colour. Conidia were then numerous. After two months there were pale cream patches amidst a general pale pink-gray shade. Colourless chlamydospores were produced in numbers, singly or in groups of two and three.

2. Standard solution + 3 % saccharose.—The mycelial growth was at first white, and, later, on the surface of the medium, compact, and of a faint pink colour, with concentric slightly-raised zones. Creamy patches occurred. Micro- and macro-conidia were formed in great numbers. The colour of the culture deepened, and the subaerial mycelium was of a fairly deep pink after two months. Chlamydospores were formed as in No. 1.

3. Standard solution + 3 % maltose.—The growth in the medium was dense and white, and on the surface a pale yellow colour. The aerial mycelium was small in amount, but micro-conidia were very numerous. Later the whole culture became pale yellow or creamy, of the same colour as the patches in Nos. 1 and 2. All three spore forms were produced.

4. Standard solution + 5 % glycerine.—The growth was white and dense within the medium. The aerial growth was sparse and white at first, becoming pale salmon-pink after two months. The colour persisted better in this culture than in the others. The three spore forms were found.

5. Standard solution + 5 % gum acacia.—The growth was strong and white. The white colour persisted after two months, especially in the compact aerial mycelium. Microconidia and chlamydospores were produced in numbers, but macroconidia were very scarce and smaller than usual.

6. Standard solution + 1 % peptone.—The submerged growth was small, flaky, and of a dirty white colour. The superficial growth was very sparse and colourless. No colour developed after two months. No macroconidia were found. Chlamydospore formation had only begun after two months.

7. Standard solution + 1 % asparagin.—The surface growth was larger than in Nos. 4 and 6, at first faintly pink and, later, white with very pale yellow patches. Only microconidia were produced.

8. Standard solution + 1·5 % citric acid.—Growth consisted of a few small flocculent masses which did not develop any colour. No spores were found.

9. Standard solution + 1 % sodium carbonate.—One very small submerged flocculent colony resembling those of No. 8 was visible after one month. No conidia were produced, but after two months chlamydospores were numerous.

Solid media :—

10. Normal potato (boiled in distilled water).—Growth was rapid, and in a few days the plug was wholly covered. The

mycelium was pale grey-pink with white flakes. It eventually became dirty yellow. All three spore forms were produced.

11. Acid potato (soaked for twenty minutes in 1 % sulphuric acid, rinsed, and boiled in distilled water).—In a few days white mycelium bearing microconidia was plentiful. This became faintly pink in colour and, later a pronounced salmon-pink. Coremial strands of mycelium were numerous and darker in colour than the mass. All three types of spores were produced.

12. Alkaline potato (soaked in 1 % sodium carbonate, rinsed, and boiled in distilled water).—The growth was not so dense as in Nos. 10 and 11, but micro- and macroconidia were found in plenty and a faint pink colour was developed. Chlamydospores were formed later.

13. Normal rice paste (boiled in distilled water).—Growth was immediate and copious. Spores were very numerous; the macroconidia measured up to $30\mu$ long after three days. Later the prevailing colour was pale pink. The colour became deeper and towards the edges of the areas of growth shaded through salmon-pink into a pale orange. Strands of mycelium were common, as in No. 11. Spore formation continued to be profuse, and chlamydospores were numerous after two months.

14. Acid rice paste (a few drops of 5 % hydrochloric acid added to a small quantity of rice moistened with distilled water). —There was no difference between this culture and No. 13 save that the colour did not become so deeply red.

15. Alkaline rice paste (a few drops of a saturated solution of sodium carbonate added to a small quantity of rice as in No. 14). —The growth was not so profuse as in Nos. 13 and 14, and the colour was slightly paler than that of No. 14.

16. Boiled tapioca paste.—Growth was slow. Only one small, pinkish area of mycelium-bearing microconidia was noted.

The fungus had already been grown on banana plugs, prune agar, glucose, meat-extract agar, French-bean agar, rice agar and sterilised hypocotyls of cashew nut seedlings, and its general characteristics in these cultures have already been reported. Small differences between the cultures of Butler and the special cultures existed, *e.g.*, in the mycelial colours of Nos. 3, 4, and 5, in the formation of macroconidia in No. 5, in the lack of spores in No. 8, in the growth and formation of chlamydospores that took place in No. 9, in the occurrence of growth in concentric raised lines in Butler's standard solution and asparagin culture whereas the same formation occurred only in the standard solution and saccharose culture, and in the absence of the pink colouration of the sclerotoid bodies which Butler noted in his acid potato and plantain cultures. With regard to sclerotoid bodies, similar stromata consisting of pseudo-parenchyma were formed in a prune agar tube culture after eight months, but they were of a dull grey-pink rather than a pure pink colour. They gave rise to conidiophores bearing microconidia, and chlamydospores were associated with them in great numbers.

Van der Bijl noted the formation in culture of what he called wart-like bodies during his study of the same *Fusarium* on carnations,* but he said nothing about their having any apparent function. Coremial strand mycelial formation is not a constant character, but it occurred in Butler's and the present cultures although on different media. As for the diagnostic characters on which Dr. Butler lays stress, the bacterial-like surface streaks already mentioned were very evident, and the colourations were practically alike. The colour differences mentioned in Nos. 3, 4, and 5 do not seem worthy of weight, despite the present tendency to lay stress on cultural colours, for it was found in these studies that salmon-pink or a shade of yellow or cream might be associated with spore formation. In any case, a certain amount of all-round variation must be allowed for, so long as it is impossible to reproduce the exact environmental conditions employed by another worker at another time. Similarly, the differences noted in Nos. 5, 8, 9 and 2 have little or no importance when regarded as possible specific distinctions.

Morphologically, the *Fusarium* under investigation and *Fusarium udum* are identical in most points. Microconidial formation takes place early and is remarkably copious. The conidiophores may be simple (fig. 12) or whorled; the former

Fig. 12. Simple conidiophores arising from creeping mycelium in a boiled rice culture, 3 days (cashew nut), × 500.

were by far the more common; the latter were found in greatest abundance in the normal rice and acid potato cultures, as also were the characteristic bundles of microconidia (fig. 13). There occurred frequently an intermediate form of conidiophore in which the main axis of the simple conidiophore of fig. 12 gave rise to short lateral branches each bearing a conidium. The surfaces of all slant cultures became and remained moist with masses of spores. The microconidia germinated readily in hanging-drops of distilled water and gave rise to one or two stout filaments which took their origin from the ends of the conidium and were observed to produce only further microconidia

* *loc. cit.*, p. 276.

or chlamydospores. The *Fusarium* conidia, if they were formed, appeared fairly late, and were three- to five-septate. They were abjuncted before they were fully mature. Measurements have been

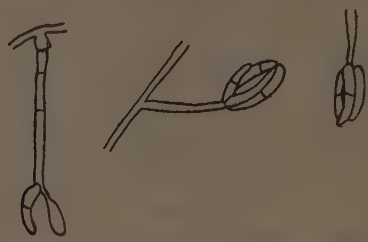

Fig. 13. Characteristic bundles of macroconidia from a cashew nut twig culture, 6 days. To the right is a younger stage of the same from an acid potato culture, × 500.

given. The three septate were, as a rule, more straight, shorter, broader in proportion, and more numerous than the five-septate spores. The larger multi-septate conidia have already been referred to. They were found only seldom, and they evidently did not occur in Butler's fungus. Such out-sized conidia are known to occur at times in species of *Fusarium* both in nature and in culture. Macroconidial production was noted only on single conidiophores. Conidial germination, as already described, corresponded with that of Butler's fungus, but there did not seem to be any difference in the chlamydospores or in the methods of their formation in culture. The morphological and cultural differences do not seem to justify the separation of the Uganda *Fusarium* from *F. udum*, and there is no doubt in the writer's mind that a careful comparison of Dr. Butler's details with the notes in this paper on the earlier cultures and the later special cultures will admit of the provisional reference of the Uganda *Fusarium* to *Fusarium udum*.

The second part of the special work undertaken to establish the exact identity of the *Fusarium* consisted of infection experiments with the Indian host of *F. udum*. Numerous seeds of pigeon-pea were sown in soil from which had been derived wilted cashew nut seedlings and which was presumably infected with the *Fusarium*, and in the laboratory tins of similar soil were inoculated with the *Fusarium* and afterwards sown with pigeon-pea. The laboratory experiments gave entirely negative results although they were repeated several times, but the plants grown in infected soil in the open contracted a wilt and died. The working of the fungus was slow, for the time which elapsed between the sowing of the seed and the deaths of the plants was eight to nine months. The percentage of deaths at the time of writing was fifty, but there were indications that more of the plants were in process of wilting. The symptoms of the disease of pigeon-pea were similar to those described from India, and the *Fusarium* was recovered from all the diseased plants and grown in culture. It

was typical of former growths with cream-yellow and pink colouration, numerous microconidia, and macroconidia measuring when three-septate up to 30$\mu$, and when five-septate up to 52$\mu$ long. Thus further evidence of the identity of the Uganda fungus with *Fusarium udum* was obtained, and it remains to add to the original diagnosis that the *Fusarium* has been found in South Africa on carnations and in Uganda on carnations, *Nigella*, *Delphinium*, *Cosmos* and cashew nut seedlings. Its occurrence on silky oak, rose apple and loquat seedlings and on *Antirrhinum* plants in association with *Heterodera radicicola*, Greef, has also been discussed. In those cases, the fungus may be said to be a facultative rather than an obligate parasite, and their study throws a little light on the conditions under which the *Fusarium* may pass from a purely saprophytic condition in the soil to one of parasitism, or on the conditions under which the original strain may give rise to new types under natural conditions. There is need for a closer study of the variations in the morphology and pathogenicity of the various strains of the *Fusarium* and for the pursuit of its higher forms, and it is hoped that further work will succeed in clearing up several points that are at present obscure.

## XLIII.—A CONTRIBUTION TO THE FLORA OF THE NEARER EAST.

W. B. Turrill.

Several small but interesting collections of plants from various parts of the Nearer East have been received recently at Kew. These have now been worked out and the specimens added to the Kew Herbarium. Since some of the plants have been collected in areas whose flora is almost unknown, it has been considered advisable to publish a list of species and localities, as a contribution to our knowledge of plant distribution in the area of the Nearer East—a convenient phrase which has been borrowed from Dr. Hogarth. The following particulars regarding the collections mentioned in this paper may be given here in tabular form :—

| | | |
|---|---|---|
| Lt. Col. F. R. Durham, O.B.E., M.C.* | 34 | Gallipoli, Macedonia, Asia Minor, Palestine. |
| Major G. W. Harris† | 31 | Greek Macedonia. |
| Mr. H. G. Butcher‡ | 11 | Island of Lemnos. |
| Miscellaneous | 5 | Greek Macedonia. |

* Director of Works, Imperial War Graves Commission.

† We are indebted to Major G. W. Harris for nearly 500 specimens of Macedonian plants, most of which have been quoted in the *Kew Bull.*, 1918, Nos. 8-9. Major Harris went through the Salonika campaign as an officer in the R.A.M.C.

‡ Mr. H. G. Butcher was formerly a student-gardener at Kew. During the war he served in the Navy, and whilst on patrol work in the Ægean Sea he visited Lemnos and brought away with him the plants mentioned in this list as collected by him.

Very little indeed is known of the flora of Gallipoli and it was not surprising to find in Col. Durham's collection several plants new to Europe and one species new to science (*Astragalus Durhamii*). It is hoped that further collections from the peninsula will be received next year.

The island of Lemnos was visited by Sibthorp and an account of his visit will be found in the Memoirs Relating to European and Asiatic Turkey and other Countries of the East, Edited from Manuscript Journals by Robert Walpole, M.A., 2nd ed., London, 1818. Plants collected by Sibthorp in Lemnos are quoted in his Florae Graecae Prodromus and in the Flora Graeca Sibthorpiana.

The Rev. H. F. Tozer also visited Lemnos, but though a small collection of plants collected by him in the Nearer East is preserved at Kew (*Kew Bull.*, 1920, p. 29), no plants collected in this island are contained in it. In his book The Islands of the Ægean, chapters xii. and xiii., there is an interesting account of the island with many references to older authors. The entire absence of trees, with the exception of a few fig-trees and other fruit-trees, is especially commented upon as giving the scenery an aspect of great desolation, though the soil is very fertile in many parts. The flora of the other islands of the Northern Ægean, with the exception of that of Imbros, is much better known. Dr. A. von Degen in the Oesterr. Bot. Zeitschr. 1891, pp. 301, 329, has given a valuable account of the flora of Samothrace and Halácsy (l.c. 1892, p. 412, 1893, p. 1) and Bornmüller (l.c. 1894, pp. 124, 173, 212) have dealt with the flora of Thasos. An interesting description of Imbros with a general account of the vegetation is given by Capt. A. G. Ogilvie in the Geographical Journal for August, 1916, p. 130.

## Systematic List.

**Anemone pavonina,** *Lam.*, var. **purpureo-violacea,** (*Boiss.*) *Hal.*

Greek Macedonia: neighbourhood of Jera Karu (between Mt. Hortiach and Lake Langaza), *Harris* 425.

The plants often included under the Linnean name *Anemone hortensis* show a wide, and, with a sufficiency of specimens, a continuous range of variation. Most authors distinguish two extreme groups variously considered as species, subspecies, or varieties, namely *A. pavonina*, Lam., and *A. stellata*, Lam. However, variations of these have been named and described and certainly all kinds of intermediates exist, whatever may be their actual status. The specimen quoted above (*Harris* 425) has exceptionally broad obovate sepals. Specimens quoted previously by the writer as *A. stellata*, Lam., are now considered as mostly intermediates between typical plants of this species or subspecies (Briquet) and *A. pavonina*, Lam.

**Helleborus cyclophyllus,** *Boiss.*

Greek Macedonia: neighbourhood of Jera Karu, *Harris* 424.

**Nigella arvensis,** *L.*
Island of Lemnos : Mudros, *Butcher.*

**Delphinium halteratum,** *S. et S.*
Greek Macedonia : Struma Valley, *Durham* 1.

**Paeonia peregrina,** *Mill.* (*P. decora,* Anders., see Bot. Mag. t. 8742).
Greek Macedonia : mountains near Lake Doiran, *Durham* 2.

**Glaucium corniculatum,** *Curt.,* var. **rubrum,** *S. et S.*

Gallipoli : Suvla Bay and coast generally, in patches. Flowers reddish orange, *Durham* 3.

**Hypecoum grandiflorum,** *Benth.*
Greek Macedonia : neighbourhood of Jera Karu, *Harris,* 447.
Island of Lemnos : Mudros, *Butcher.*

**Matthiola tricuspidata,** *R. Br.*
Asia Minor : Nagava, sea shore. Very sweet smelling, *Durham* 4.

**Cardamine graeca,** *L.*
Greek Macedonia : neighbourhood of Jera Karu, *Harris* 441, 442.

**Erophila verna,** *L.*
Greek Macedonia : neighbourhood of Jera Karu, *Harris* 422, 450.

**Lepidium spinosum,** *L.*
Island of Lemnos : Mudros, *Butcher.*

**Capparis sicula,** *Duh.*
Gallipoli : Anafarta and Cape Hellas. Thorny, trailing habit, flowers white fading to bluish purple, *Durham* 5.

**Dianthus pubescens,** *S. et S.,* var. **glandulosopubescens,** *Hal.*
Island of Lemnos : Mudros, *Butcher.*
This species occurs in Attica and Eubœa and is also recorded from several places in the Peloponnesus. The variety, which is distinguished by the glandular-pubescent calyx, was described from a plant collected on Mt. Pateras in Attica.

**Dianthus tenuiflorus,** *Griseb.*
Greek Macedonia : neighbourhood of Jera Karu, *Harris* 444.

**Hypericum olympicum,** *L.*
Greek Macedonia : near Lake Doiran, *Durham* 6.
Island of Lemnos : Mudros, *Butcher.* A dwarf form.

**Althaea cannabina,** *L.*
Greek Macedonia : near Lake Doiran, *Durham* 7.

**Linum flavum,** *L.* (sensu lato).
Palestine : near Jerusalem, orange yellow flowers, *Durham* 8.

**Linum tenuifolium,** *L.*
Greek Macedonia : neigbbourhood of Jera Karu, *Harris* 446.

**Geranium lucidum,** *L.*

Greek Macedonia: neighbourhood of Jera Karu, *Harris* 443.

**Erodium cicutarium,** *L. Her.*

Greek Macedonia: neighbourhood of Jera Karu, *Harris* 449.

**Haplophyllum Buxbaumii,** *Poir.*

Gallipoli: Cape Hellas, sandy sea beach. Bright light orange yellow flowers, *Durham* 9.

**Paliurus Spina-Christi,** *Mill.*

Gallipoli: fairly frequent. Bright yellow inflorescences and very attractive light fresh green foliage, much eaten by insect life, *Durham* 10.

**Trifolium hirtum,** *All.*

Greek Macedonia: grown from seed collected near Paprat, on the southern slopes of the Krusa Balkan, by *J. M. Russell*, 1918. Flowered at Richmond, Surrey, August 1920.

**Astragalus Durhamii,** *Turrill* (Leguminosae-Galegeae); *A. ajubense*, Bge., valde affinis sed foliolis saepissime minoribus, vexillo elliptico-ovato latiore differt.

*Caules* glabri, leviter longitudinaliter costati, teretes. *Folia* caulina usque ad 1·7 dm. longa, glabra vel fere glabra, pinnis circiter 30 elliptico-lanceolatis vel oblongo-lanceolatis apice obtusis saepe breviter apiculatis basi rotundatis petiolulatis petiolulis 1 mm. longis costa in pagina utraque prominente nervis lateralibus in pagina superiore impressis in pagina inferiore prominentibus; stipulae lanceolatae, apice attenuatae, usque ad 2·7 cm. longae, interdum pilis albis longis paucis instructae. *Inflorescentiae* axillares, multiflorae, globosae; pedunculi usque ad 5·5 cm. longi, pilis albis paucis dispersis praediti; bracteae lineari-lanceolatae, apice attenuatae, circiter 1 cm. longae, margine longe albo-ciliatae. *Calyx* longe albo-pilosus, tubo 9 mm. longo, dentibus lineari-acicularibus usque ad 9 mm. longis inter se subaequalibus. *Corolla* intense lutea, vexillo 2·2 cm. longo, lamina late elliptico-ovata apice leviter emarginata 1·5 cm. longa 1·2 cm. lata, alis 2·1 cm. longis 4 mm. latis, carina 2·1 cm. longa 6 mm. lata basi filamentorum tubo distincte adnata. *Filamenta* glabra. *Ovarium* longe denseque albo-pilosum; stylus inferne pilis albis dispersis instructus.

Gallipoli: fairly distributed. The plant grows about 3 feet high and has very handsome, deep yellow flowers and beautiful foliage, *Durham* 11.

The species of *Astragalus* described above belongs to a small group whose known distributional area has not hitherto included Europe. The affinity of our plant with the *A. ajubensis* of Bunge is undoubtedly very close. Indeed, a large series of specimens might make it advisable to consider them conspecific. At present *A. ajubensis* is known with certainty only from Mt. Ajub near the ruins of Persepolis in Southern Persia. The section *Alopecias*, to which our plant belongs, consists of two series, *A. Durhamii* being placed in the *Ebracteolati*, and in the subseries *Megalotropi*.

In this subseries it is further delimited by its globose and long peduncled inflorescences. From species, other than *A. ajubensis*, with similar characters (e.g., *macrocephalus, finitimus, hamadanus*) it is easily distinguished by its indumentum, the shape and teeth of the calyx and the details of corolla structure. The nearest affinity with a species occurring in Europe is that with *A. ponticus*, Pall., from which it differs in its glabrous stems and nearly glabrous foliage, its long peduncle, linear-acicular calyx teeth which are subequal and approximately as long as the calyx-tube, the larger corolla and broader vexillum, and in the lamina of the carina being broader than that of the wings.

**Astragalus macedonicus,** *Heldr. et Char.*

Greek Macedonia : Kireckoj, north of Salonika, *Durham* 12 : neighbourhood of Jera Karu, *Harris* 438.

**Hedysarum varium,** *Willd.*

Gallipoli : only seen at Byick Tepe, Ulgar Dere. A very beautiful plant with lemon yellow flowers with deeper orange and purple blotches, *Durham* 13.

This is apparently a species new to Europe. It is widely spread through Asia Minor, from Bithynia and Lydia, to Transcaucasia and Mesopotamia.

**Vicia dasycarpa,** *Ten.*

Greek Macedonia : grown from seed collected on the southern slopes of the Krusa Balkan, probably near Paprat, by *J. M. Russell*, flowered at Richmond, Surrey, July 1920.

**Vicia grandiflora,** *Scop.*

Greek Macedonia : neighbourhood of Jera Karu, *Harris* 440.

**Orobus sessilifolius,** *S. et S.*

Greek Macedonia : neighbourhood of Jera Karu, *Harris* 436.

**Potentilla micrantha,** *Ram.*

Greek Macedonia : neighbourhood of Jera Karu, *Harris* 439.

**Saxifraga graeca,** *Boiss. et Heldr.*

Greek Macedonia : neighbourhood of Jera Karu, *Harris* 437.

**Turgenia latifolia,** *Hoffm.*

Greek Macedonia : neighbourhood of Jera Karu, *Harris* 434.

**Valerianella olitoria,** *Poll.*

Greek Macedonia : neighbourhood of Jera Karu, *Harris* 432.

**Doronicum caucasicum,** *M.B.*

Greek Macedonia : neighbourhood of Jera Karu, *Harris* 433.

**Calendula arvensis,** *L.*

Island of Lemnos : Mudros, *Butcher.*

**Specularia pentagonia,** *DC.*

Gallipoli : fairly frequent in dry valleys and on dry slopes. Creeping rather than erect, with bright mauve flowers, *Durham* 14.

**Statice sinuata,** *L.*

Island of Lemnos : Mudros, *Butcher.*

**Erythraea Centaurium,** *L.*
Greek Macedonia : neighbourhood of Jera Karu, *Harris* 421.

**Symphytum bulbosum,** *Schimp.*
Greek Macedonia : near Jera Karu, *Harris* 419.

**Myosotis collina,** *Hoffm.*
Greek Macedonia : near Jera Karu, *Harris* 453.

**Lithospermum purpureocœruleum,** *L.*
Greek Macedonia : neighbourhood of Jera Karu, *Harris* 420.

**Echium plantagineum,** *L.*
Island of Lemnos : Mudros, *Butcher.*

**Verbascum Blattaria,** *L.*
Greek Macedonia : grown from seeds collected to the south of Karamudli, June 29th, 1917, flowered at Richmond, Surrey, May 27th, 1920, *Turrill* (seed-number) 65.

One interesting morphological fact concerning the specimens quoted above seems worth recording. In one plant the lowest flower of the raceme, or apparent raceme, and the first to open, possessed only four stamens, all fertile, with no trace of the adaxial fifth. The remaining flowers, which opened later, possessed each five stamens, with the adaxial one frequently shorter and with a smaller anther.

The genus *Celsia* is closely related to the genus *Verbascum* and the only generic difference is in the number of the stamens, five in *Verbascum* and four in *Celsia*. The sections *Blattariae* and *Blattarioidea* (sensu Boissier, Fl. Or. iv.) of *Verbascum* consist of species having the same racemose, or apparently racemose, type of inflorescence as that found in the genus *Celsia*. It is also interesting to note that both genera show two similar divergent groups, the one with all the stamens having their anthers reniform and mediofixed, the other with the anthers of two of the stamens adnate-decurrent, and the anthers of the remainder reniform and mediofixed. It is probable that the existing classification which separates the two genera solely on the number of fertile stamens is very artificial.

**Celsia Daenzeri,** *Fauché et Chaub.*
Greek Macedonia : plants grown from seed collected near Salonika, received from the Rev. Canon Fowler and Miss A. Taylor, 1920.

This species extends from Messenia and Laconia to Macedonia. Halácsy (Conspect. Fl. Graec., ii., p. 397) quotes a specimen collected in Thessalia : prope Malakasi in Pindo (Sintenis it. thessal. n. 632), as *Celsia Boissieri*, Heldr. et Sart. In the Kew Herbarium the specimen under this number is *Celsia Daenzeri*, Fauché et Chaub., and not *C. Boissieri*, Heldt. et Sart., of which species the writer has seen authentic specimens only from Attica.

**Digitalis lanata,** *Ehrh.*
Gallipoli : white and brown flowers, *Durham* 15.
Greek Macedonia : cultivated from seeds, *J. Anderson.*

**Trixago Apula,** *L.*
Gallipoli : fairly frequent and grows in masses, *Durham* 16.

**Orobanche Mutelii,** *F. Sch.*
Gallipoli : Kelia, light "Cambridge-blue" flowers, *Durham* 17.

**Vitex Agnus-castus,** *L.*
Gallipoli : from the region by the British Cemeteries, *Durham* 18.

**Thymus atticus,** *Celak.*
Gallipoli : not frequent, white flowers, *Durham* 19.

**Thymus capitatus,** *Hoffm. et Lk.*
Gallipoli : from the region by the British Cemeteries, *Durham* 20.
Island of Lemnos : Mudros, *Butcher.*

**Prunella alba,** *Pall.*
Greek Macedonia : near Lahana, on roadsides, *Durham* 21.

**Stachys angustifolia,** *M.B.*
Greek Macedonia : Lahana, *Durham* 22.

**Stachys italica,** *Mill.*, forma.
Island of Lemnos : Mudros, *Butcher.*
This plant has not been exactly matched. It comes nearest to plants from Southern Bulgaria which belong to *Stachys italica* in a broad sense. The *italica-germanica* group of the genus *Stachys* is represented in the Eastern Mediterranean by a host of small species which are very often connected together by intermediates. On a provisional classification which has been worked out for the Balkan Peninsula material at Kew the Lemnos plant is regarded as a form of *S. italica*, Mill., sensu lato.

**Ballota acetabulosa,** *Benth.*
Island of Lemnos : Mudros, *Butcher.*

**Teucrium Polium,** *L.*
Gallipoli : all over the lower regions. It frequently grows in very neat bushes, *Durham* 23.

**Thymelaea tartonraira,** *All.*
Gallipoli : from the region by the British Cemeteries, *Durham* 24.

**Euphorbia apios,** *L.*
Greek Macedonia : neighbourhood of Jera Karu, *Harris* 423.

**Quercus coccifera,** *L.*
Gallipoli : from the region by the British Cemeteries, *Durham* 25.

**Cephalanthera rubra,** *Rich.*
Gallipoli : Byick Tepe, Ulgar Dere, about 900 feet altitude, on a dry spot, *Durham* 26.

**Orchis hircina,** *Crantz.*
Greek Macedonia : neighbourhood of Jera Karu, *Harris* 427.

**Orchis romana,** *Seb.*
Greek Macedonia: neighbourhood of Jera Karu, *Harris* 426, 430.

**Ophrys mammosa,** *Desf.* (*O. atrata*, Lindl.).
Greek Macedonia: neighbourhood of Jera Karu, *Harris* 429.

**Iris Reichenbachii,** *Heuffel.*
Greek Macedonia: neighbourhood of Jera Karu, *Harris* 428.

**Allium margaritaceum,** *S. et S.*
Greek Macedonia: near Lake Doiran, *Durham* 27.

**Allium maritimum,** *Raf.*
Greek Macedonia: Kirechkoj, near Salonika, *Durham* 28.

**Allium pulchellum,** *Don.*
Greek Macedonia: Kireckoj, near Salonika, *Durham* 29.
Palestine: Gaza, *Durham* 30.

**Allium rotundum,** *L.*
Gallipoli: Suvla Bay, fairly frequent, 18 to 24 inches high, flower deep purple, *Durham* 31.

**Muscari pyramidatum,** *Vel.*
Greek Macedonia: neighbourhood of Jera Karu, *Harris* 431.

**Ornithogalum pyrenaicum,** *L.*
Gallipoli: fairly frequent, *Durham* 32.

**Imperata arundinacea,** *Cyril.*
Greek Macedonia: neighbourhood of Jera Karu, *Harris* 435.

**Stipa pennata,** *L.*
Greek Macedonia: Kireckoj, near Salonika, *Durham* 33.

**Aegilops triaristata,** *Willd.*
Gallipoli. *Durham* 34.

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## XLIV.—DUNN'S WATTLE.

Complete specimens of the remarkable Acacia known by the above name, and having phyllodes up to 1½ feet long, have just been received at Kew from Mr. E. J. Dunn who discovered it in N.W. Australia. Mr. J. H. Maiden had previously described the tree as *A. sericata* A. Cunn. var. *Dunnii*, (Ewart and Davies, Flora of the Northern Territory, p. 336) and Mr. Dunn therefore sent leaves and pods of what he considered typical *A. sericata* to Kew for comparison with the supposed variety. The specimens received as *A. sericata*, however, prove to be different in their winged pods and glabrous phyllodes from Cunningham's type at Kew. They agree exactly with *A. platycarpa*, F. Muell. (Journ. Linn. Soc. III. p. 145) the type of which is also in the Kew Herbarium. Bentham placed the two together in his revision of the genus (Trans. Linn. Soc. XXX. p. 483) under the name of *A. sericata* which he described as having glabrous or puberulous

phyllodes. The ripe fruit now received proves that there are two species, one with glabrous leaves and winged pods (*A. platycarpa*, F. Muell.) the other with puberulous leaves and obtuse-edged pods (*A. sericea*, A. Cunn.). Dunn's Wattle combines characters of both, having glabrous phyllodes and wingless pods. It constitutes in fact a distinct and very interesting species. A description of the plant is as follows :—

**A. Dunnii,** *Turrill*, sp. nov., affinis *A. platycarpae*, F. Muell. sed phyllodiis multo majoribus glandulis excurrentibus et leguminibus exalatis differt.

*Arbor* glauca, glaberrima, in ramos plures erectos simplices teretes 4-5m. altos basi 2-3 cm. diam. apice florigeros divisa. *Phyllodia* pendula, ovato-falcata, dimidiata, coriacea, lucida, 20-50 cm. longa, distanter adpresse serrata, apice obtusa, in petiolos breves angustata, 4-nervia, crebre reticulato-venosa, nervis cum margine confluentibus, glandulis marginalibus dentes terminantibus. *Capitula* flava, circiter 20-flora, paniculas 20-40 cm. longas caules terminantes formantia, 1-2 cm. diam., pedunculis 1-4-nis 1-2 cm. longis. *Flores* flavi, 4 mm. longi. *Calyx* in lobos 5 divisus, lobis 3 mm. longis ligulatis apice hirsutis incrassatis. *Corolla* calyce paullo longior, in lobos 5 oblanceolatos divisa. *Stamina* ∞, 4 mm. longa. *Legumen* oblongum, complanatum, falcatum, inter semina paullo contractum, suturis obtusum, exalatum, apice basique acutum, 9-11 cm. longum, valvis lignosis reticulato-venosis. *Semina* 12-14, transversa, 1.2 cm. longa, 5 mm. lata, brunnea, lucida, basi strophiolo breviter tecta, endocarpio membranaceo inclusa. *Acacia sericata*, A. Cunn., var. *Dunnii*, Maiden, in Ewart and Davies, The Flora of the Northern Territory, p. 336.

N.W. Australia.—From fissures in hard quartzite rock near Victoria River, Northern Territory; flowers May, fruit June, 1922. *E. J. Dunn.*

## XLV.—MISCELLANEOUS NOTES.

**Pear Wood.**—The wood of *Pyrus communis*, *L.* and its cultivated varieties the garden pears, is rarely seen in quantity in merchants' yards and the reason is easily found, for trees are not cut in large numbers except at the clearance of old orchards, and even then they are often disposed of as firewood, not as useful timber. The trunks of well grown trees however, if sound, 8 inches and upwards in diameter and clear of branches for at least five feet, are worth offering for sale, while the trunks of some of the large perry pears from the orchards of Herefordshire, Worcestershire and Gloucestershire are valuable. The wood has very small pores and fine medullary rays, is heavy, firm, close grained, even in texture, and pinkish or pale reddish-brown, with little distinction in colour between sap-wood and

heart-wood except in very old trees. It finishes with a very smooth surface in whichever way it is worked, hence its value for carving and turnery. The wood is also very popular for the manufacture of instruments and is widely used for T squares and set squares. Another use for the wood is the manufacture of camera shutters and for this purpose it is stained black. Treated in a similar way it is sometimes used as a substitute for ebony in the manufacture of cabinets and small fancy articles. The wood, however, requires very careful seasoning, otherwise it twists. As a rule persons who have a few trees to dispose of would do better by offering them to firms who specialise in cameras or scientific instruments rather than to a local timber merchant. W. D.

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**The Douglas Fir Chermes.***—During the last few years foresters have been alarmed at the rapid spread of the Douglas Fir Chermes (*Chermes cooleyi*), and in view of the fact that closely allied insects make it difficult to cultivate certain silver firs and the Weymouth pine, the Forestry Commission decided to investigate thoroughly the life-history of the Douglas Fir Chermes, in order that an idea could be formed of the injury it is likely to cause. The work was entrusted to Mr. R. N. Chrystal, B.Sc., under the direction of Dr. Munro, the Commission's Entomologist, and by arrangement with the Director the laboratory work was conducted at Kew. *Chermes cooleyi* was imported into this country from Western N. America and Mr. Chrystal entered upon his investigations with previous knowledge of his subject as he has undertaken similar research work in Stanley Park, Vancouver, for the Canadian Entomological Service. The work was commenced in November and was continued throughout 1921 and the summer of 1922. The result of the 1921 work has just been published in bulletin form by the Forestry Commission, and both they and the author are to be congratulated upon the production of a very clear and well illustrated contribution to the life history of *Chermes cooleyi* in Britain compared with its more fully known life history in British Columbia. As is the case with other species of Chermes, *C. cooleyi*, in order to complete its life cycle, requires species of two different genera of trees, and in this case one is the Douglas fir (*Pseudotsuga Douglasii*), the other a Western N. American spruce preferably *Picea sitchensis*. In British Columbia all the stages of the life history of the insect are present, but in Britain the most injurious stage, which causes galls on *Picea sitchensis*, is absent, although other stages occur on that species. Fortunately the insect confines its depredations to the leaves, therefore there is much less injury caused than by allied species that attack young shoots and bark. Although the investigations are not

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* Forestry Commission Bulletin, No. 4, The Douglas Fir Chermes (*Chermes cooleyi*), 1922, price 2*s*. net. (Obtainable from H.M. Stationery Office, Imperial House, Kingsway, W.C. 2).

completed it would appear that they have gone far enough to warrant the investigator in concluding that the Douglas Fir Chermes is not causing very serious injury to its hosts in this country, and that it is not likely to have such a disastrous effect upon Douglas fir as was at one time feared. The bulletin indicates a vast amount of painstaking work and it has laid the foundation for what we hope will result in a complete investigation into the allied species that are so prevalent upon some of our trees. Such a work proves how necessary it is for science and practice to work hand in hand. The time of the practical forester is fully employed upon cultural work, he has not been trained to a critical knowledge of entomology neither has he time for organised research, therefore it is to the trained entomologist that he must turn for his knowledge of the life history of injurious forest insects and the necessary methods of control. On his side the economic entomologist should present his work in such a manner that it is easily understood by those responsible for the practical work of the forest and the suggested methods of control should be of a practical nature, and, whenever possible, such as may be put into practice by ordinary forest workmen. Such ideas seem to dominate the work of Dr. Munro and it is towards this end that he appears to have directed the work of Mr. Chrystal. W. D.

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**List of Botanical Papers by the late Mr. J. R. Drummond.**— The following list was held over from the obituary notice of the late Mr. J. R. Drummond which was published in *K.B.* 1921, p. 123.

On a new *Scirpus* from Baluchistan and certain of its allies. (Journ. Asiat. Soc. Bengal, lxxiii. pt. ii. pp. 137–148, 1904.)

Notes on *Agave* and *Furcraea* in India [with D. Prain]. (Bengal, Dept. Land Records and Agriculture, Bulletin 8, 1905, 195 pp., Calcutta, 1906; reprinted in The Agricultural Ledger, 1906, No. 7, pp 77–271.)

The literature of *Furcraea* with a synopsis of the known species. (Report, Missouri Bot. Gard., 18, pp. 25–75, pl. 1–4, 1907.)

*Chlamydites:* a new genus of Compositae. (Kew Bulletin, 1907, pp. 90–92.)

*Agave Wrightii*, J. R. Drummond. (Bot. Mag. 1909, t. 8271.)

*Agave lurida.* [with references to other species, and a key to their identification]. (Kew Bulletin, 1910, pp. 344–349.)

Native habitat of *Aster Falconeri.* (Gard. Chron. 1910, xlviii, p. 2.)

The Grewias of Roxburgh. (Journal of Botany, 1911, pp. 329–337, 357–363.)

*Saussurea Veitchiana*, J. R. Drummond & Hutchinson. (Bot. Mag. 1911, t. 8381.)

Obituary notice of R. H. Beddome. (Proc. Linn. Soc., cxxiii. 1911, pp. 32–34.)

*Agave disceptata*, J. R. Drummond. (Bot. Mag. 1912, t. 8451.)

Asiatic species of Sageretia [Note]. (With T. A. Sprague.). (Kew Bulletin, 1914, p. 175.)

Miliusa and Saccopetalum (Family Anonaceae). (Journ. Indian Botany, i. pp. 162–168, 1920.)

A revision of *Isopyrum* (Ranunculaceae) and its nearer allies [with J. Hutchinson]. (Kew Bulletin, 1920, pp. 145–169, ff. 1–8.)

"In 1888 . . . Mr. J. R. Drummond, then Deputy Commissioner of Karnál, was invited to draw up a report on the Panjáb saltworks actually in use in the manufacture of barilla, and this was furnished to the Madras Government." (Watt, Commercial Prod. of India, p. 113.)

Several descriptions of new species in the Kew Bulletin.

Mr. Drummond presented to the Library the last ten volumes of the Journal of the Bombay Natural History Society.

In 1910 he presented a transcript of the lists of determinations, localities and other information, contained in Mr. J. F. Duthie's Field Books relating to the collections in the herbarium formed by Mr. Duthie for the Botanical Department of Northern India. This transcript fills 8 quarto volumes, each of about 300 pages, and was made under Mr. Drummond's supervision and entirely at his expense.

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**An Alpine A B C.***—This is a simple guide for the amateur and beginner in rock-gardening. It consists of some general introductory notes on the cultivation of rock and alpine plants, followed by an alphabetical list of species relatively easy to grow. Short notes regarding treatment and propagation are given for most species, together with the height of the plant and the colour of the flowers. W. B. T.

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**The Imperial Department of Agriculture, West Indies.**—With the establishment of the West Indian Agricultural College at St. Augustine's, Trinidad (see *K.B.*, 1920, p. 81; 1922, p. 255), the headquarters of the Imperial Department of Agriculture have been transferred from Barbados to Trinidad.

It will be remembered that the Committee appointed by the Secretary of State for the Colonies to consider the advisability of founding an Agricultural College in the West Indies recommended that "an intimate relationship should be established between the Imperial Department of Agriculture and the Tropical Agricultural College" (see *K.B.*, 1920, p. 89); a proposal which met with the approval of the Secretary of State.

It was also recommended and approved that Sir Francis Watts, Imperial Commisioner of Agriculture, should become the first Principal of the new College and should continue to act as Imperial Commissioner.

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* An Alpine A B C and List of Easy Rock Plants, by A. Methuen. Methuen & Co., Ltd. London, 1922. 1*s*. 6*d*. net.

The Royal Botanic Gardens, Kew, have been so closely associated with the establishment of the Imperial Department of Agriculture since 1898 (see *K.B.*, 1898, pp. 234-237) when Dr. (now Sir Daniel) Morris, then Assistant Director of Kew, was appointed Commissioner, that we take pleasure in publishing the following copy of the letter from the Acting Governor of Barbados written to Sir Francis Watts, Principal and Commissioner of Agriculture, on the occasion of the transfer of the headquarters of the Imperial Department, following upon its amalgamation with the West Indian Agricultural College :—

"As your departure will mark the close of the long association of this Colony with the Headquarters of the Imperial Department of Agriculture, I cannot let the occasion pass without an expression of regret at the termination of this association between the Colony and a Department whose work has been a landmark in the history of the West Indian Colonies. I beg also to be allowed to express the cordial gratitude of the Government of Barbados for the valuable and ready assistance which the Imperial Department has rendered the local Government on numerous occasions, as well as for many personal courtesies from yourself. In bidding farewell to the Imperial Department, may I also assure you of the warm good wishes of the Barbados Government for the success and prosperity of the Agricultural College in which the Department will now be merged, and of our confident hope that the establishment of the College will prove to be a great step forward in the development of scientific tropical agriculture not only in the West Indies but also in a wider field."

The West Indian College was opened on October 16th by Sir Samuel Wilson, Governor of Trinidad and Tobago. Eighteen students have been enrolled, three being post-graduates.

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**Museum No. 4.**—The Forestry needs of the Empire so clearly demonstrated at the British Empire Forestry Conference in 1920 and more particularly the critical stage reached in deforestation in the British Isles as a result of the demands for timber during the war, have directed attention to the urgent necessity of providing for the future timber supply in the British Isles. The public generally have very little conception of the problems connected with British Forestry and but limited opportunity of becoming acquainted with them. Visitors to Kew are afforded in Museum No. 4, an opportunity of studying the diversity of problems which are embraced under "Forestry." For the majority such visits to a museum are their only means of obtaining a knowledge of the subject, and it is for this reason that this comprehensive collection of British Forestry exhibits has been got together. The collection contains specimens typical of British grown timber; many examples of the almost unlimited uses to which home grown timber is put in every-day life and exhibits of the various stages of manufacture of the articles made from timber; examples of the principal fungus and insect pests that demand the forester's attention, and photographs of forest

scenery and individual trees. Descriptions of the exhibits are provided in an Official Guide which has been prepared more with the idea of providing a text-book than a mere catalogue. The Guide was published in 1919 at 2*s*., but the Controller of H.M. Stationery Office recognising that full information about the collections should be made available to as large a section of the public who visit Kew as possible, has agreed that the Guide may now be sold at 1*s*. The price of the Official Guide to Museum No. 1 is also 1*s*., that of Museum No. 2, 6*d*., and the Catalogue of Portraits of Botanists, 6*d*.

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**The University Botanic Garden, Cambridge.***—A systematically arranged list of the plants growing in the University Botanic Gardens, Cambridge, has recently been published, which contains many interesting notes on their history, habits, and economic uses. The distribution and chief points of the more important genera are given and well reproduced plates accompany the more interesting and important species. A key plan to the Gardens is provided, with references to the page on which the description of the plant occurs, and by it a visitor can easily find any particular plant or genus. The botanical explanations provided in the Introduction, Glossary, and Notes on Leaves permit the book being used by those not intimately acquainted with botanical terminology, whilst an alphabetically arranged Index assists those unfamiliar with the systematic arrangement adopted.

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**Botany of Bihar and Orissa.**†—We welcome Pt. 4 of Mr. Haines' Botany of Bihar and Orissa. It is paged 419-754 and completes the account of the flora up to the end of *Labiatae*. Pts. 2 and 3 have already been issued Pt. 3 this year, Pt. 2 last. Pt. 1, which will appear later, is reserved for the "Introduction and General Remarks on the Botany of the Province." The size is small 8vo. The order of families adopted in the Flora of British India has been followed in the main, but a few exceptions will be found as noted on p. 1 (Pt. 2), e.g., the *Euphorbiaceae* are described immediately after *Tiliaceae*. The book is remarkably well printed. This makes the use of rather small type not only unobjectionable but actually useful, for it enables a large quantity of information to be included. Keys for each family and each genus have been drawn up on a simple plan made possible by the author's intimate acquaintance with the living flora. In addition to the information thus given a short description of each species is added, with supplementary notes in smaller type printed below as in the Flora of British India. S. T. D.

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* Guide to the University Botanic Garden, Cambridge, by H. Gilbert-Carter, Director of the Garden. Camb. Univ. Press, 1922.

† Botany of Bihar and Orissa, Part IV., by H. H. Haines, C.I.E., F.C.H., F.L.S. Adlard & Son & West Newman, Ltd., London, 1922, Rs. 13 As. 8.

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